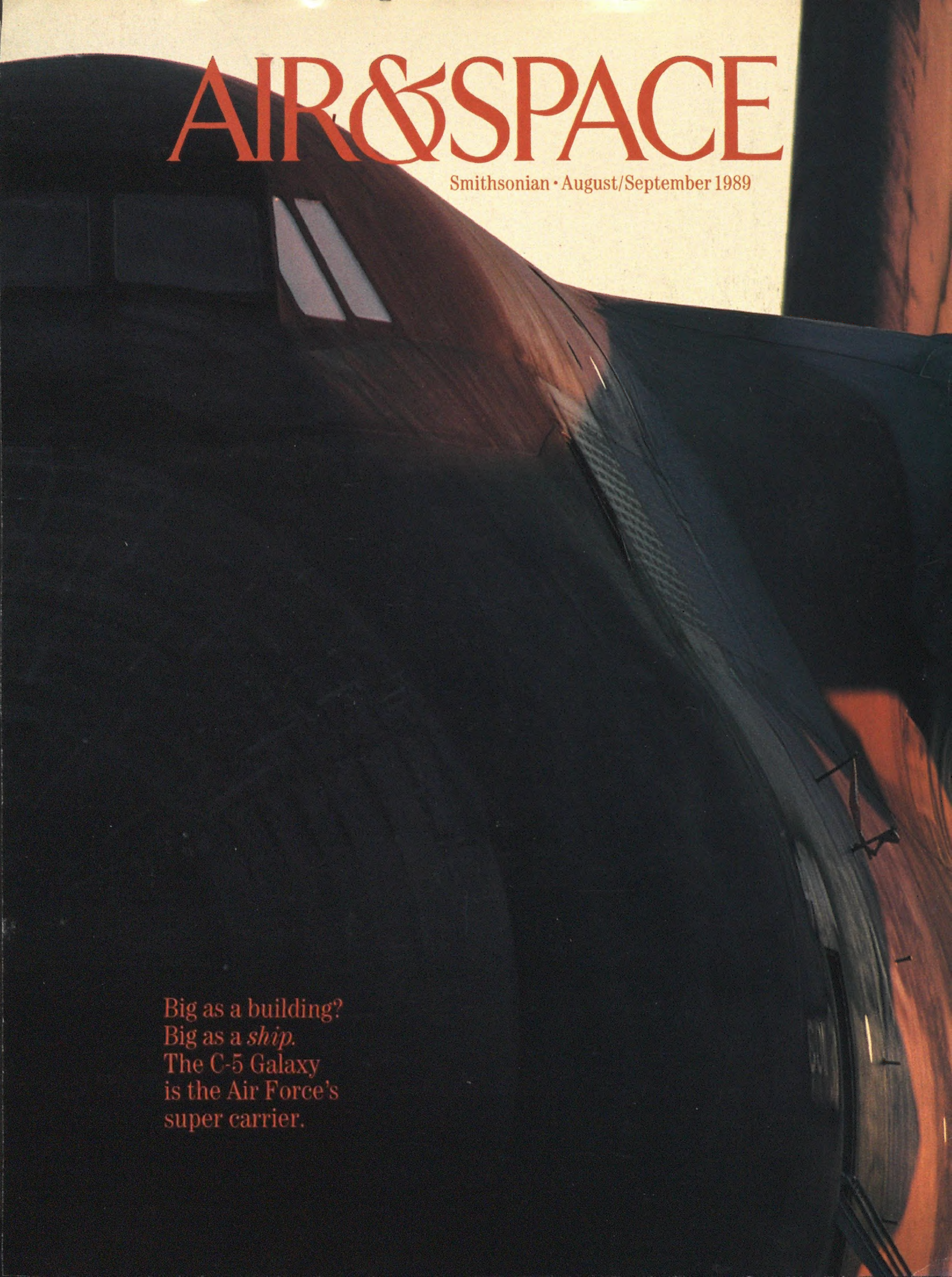


AIR&SPACE

Smithsonian • August/September 1989

Big as a building?
Big as a *ship*.
The C-5 Galaxy
is the Air Force's
super carrier.


LANDS' END

Bill Rice, the bug, the plow, and the Lands' End Interlochen Knit Shirt

Bill Rice, ready to meet the President in his favorite Interlochen Knit Shirt.

There wasn't much moving on that shimmering hot summer day not long ago, on a West Texas ranch. Just a skittish lizard, here and there. And a tractor, plowing the fields, driven by a man named Bill Rice.

Now, summertime and bugs seem to go together like bacon and eggs. So it wasn't surprising that pretty soon, a bug crawled down into the Lands' End Interlochen Knit Shirt that Bill happened to be wearing that day.

(While we have gotten pretty well acquainted with Bill Rice, we can't tell you anything about this bug, whether it was a brave bug or an ornery bug, a wise old bug or a foolish young bug. It disappeared without giving any interviews.)

Anyway, we'll let Bill tell you what happened at this point, in his own words.

"There wasn't room for me and the bug, so I yanked the shirt off and just hung it on the back of my tractor.

"Well, to make a long story short, the shirt fell down and I accidentally plowed it under. After I plowed it back up and threw it in the washing machine, it was still as good as new. Now that's a well-made shirt."

A shirt good enough to meet the President.

At this point in the story, as Bill talked to us, he began to warm to the topic of our Interlochen Knit Shirts.

"I wear them everywhere I go. Working out here on the ranch, and going into town too."

Bill says it's the comfort of the shirt that's got him sold. Along with the way it looks. (He owns six of the shirts he's pictured in here!)

"If I was going to meet the President," says Bill with a twinkle in his blue eyes, "I'd wear this shirt."

What's so special about our Interlochen Knit?

As its name somewhat prosaically implies, it's knit with an "interlocking" stitch to create a fabric that is especially lofty and plush. Of pure combed cotton, no less, for surpassing softness next to the skin.

In one of our more exuberant moments, we once declared that our Interlochen Knit Shirt is absolutely "COTTON BALL SOFT!"

More unusual than the knit fabric itself is the fact that our Interlochen is even tailored with a soft touch. The collar is taped, the shoulder and armhole seams neatly single-needle stitched, the placket smoothly finished inside—all so no rough edges of fabric ever come between you and the softness of our Interlochen.

Why take such pains with a simple knit shirt? For the same reason we add extra features to our Oxford Shirts, our Corduroy Pants, our Canvas Attaches:

Quality is one of the ruling principles of The Lands' End Experience. And our customers seem to appreciate that.

Listen to Bill Rice again: "Out here, we bust our butts to make a living. And when we spend money, we want quality. That's why I buy from Lands' End."

There's more to The Lands' End Experience.

To make sure our kind of Quality is accessible to as many people as possible, we insist that it always be accompanied by Value. As Direct Merchants, we deal directly with our manufacturers, sell directly to our customers, to deliver the utmost for the dollar.

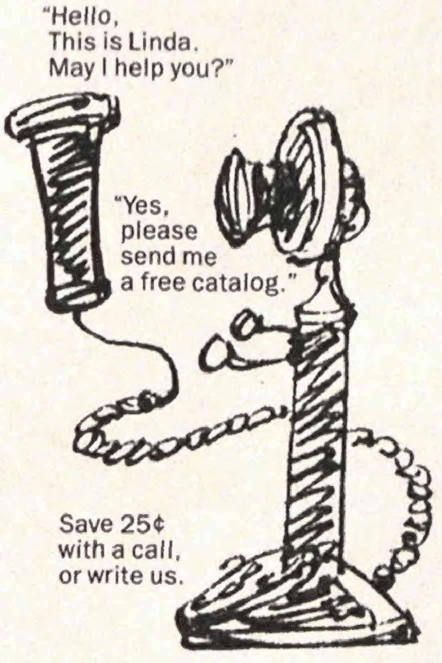
Completing The Lands' End Experience is our efficient, enthusiastic brand of Service.

We ship most orders within 24 hours after we hear from you. Back everything we sell with an emphatic guarantee that reads, simply, GUARANTEED. PERIOD.* And keep our "store" open 24 hours a day, seven days a week.

Why not call one of our operators today, toll-free at 1-800-356-4444, and let them introduce you to The Lands' End Experience? They're famous for their friendliness.

So friendly are they that sometimes, our customers are encouraged to tell them the wildest stories you've ever heard. Like the one, not long ago, about the Texas farmer who plowed under one of our knit shirts.

Now, who'd believe that?



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AIR&SPACE
Smithsonian

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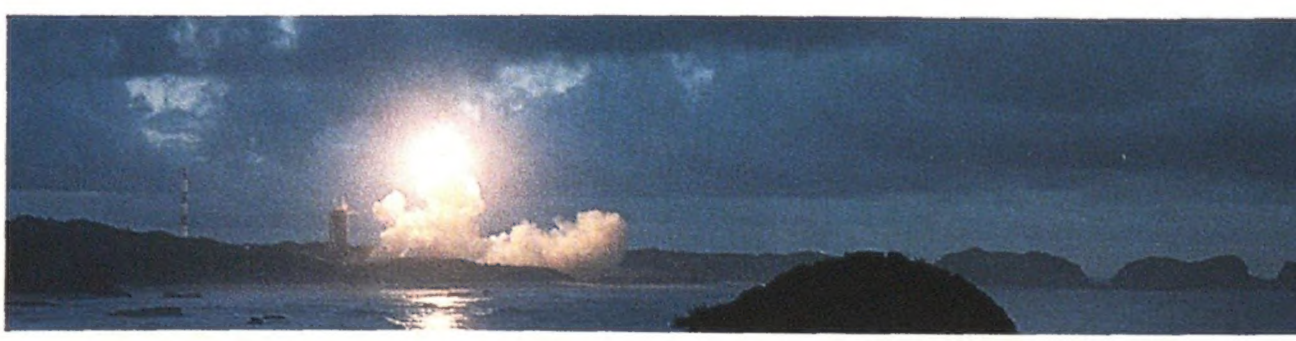

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Cover: *The massive Lockheed C-5 Galaxy airlifter is portrayed in repose by photographer Frederick Sutter.*

Two Cultures

By the standards of most of my friends, I am not much of a book collector. But I am particularly fond of a slim book of only 58 pages, which I inherited from my father. A photograph of a bald, somewhat pudgy man with heavy-rimmed glasses stares from the dust jacket. A little green label inside the front cover tells me that it cost $1.75 at the Indiana University Bookstore. Published in 1959, the book, *The Two Cultures and the Scientific Revolution* by C.P. Snow, still haunts us.

Snow pointed out that our society comprises two cultures that speak right past each other, neither comprehending what the other is saying. One culture consists of scientists and engineers with a rational, quantitative world view and a mild disdain for qualitative thinking. The other culture is made up of humanists who look at the world lyrically and are unimpressed by numbers and formal logic.

A recent *New York Times* article by Edward B. Fiske points out that even the two-culture description fails to depict the seriousness of the gap today. He refers to the exclusion of engineering courses from the standard arts and sciences college curriculum. How can we pretend that we are training well-rounded citizens, he asks, when we keep from them all knowledge about the machinery at work to change our everyday lives and our entire culture?

How did our society get this way? And what can we do about it? At the National Air and Space Museum, we have the opportunity to try to build bridges between the two cultures. With close to 10 million visitors a year, we evidently are appealing to more than just the technological communities. By means that we do not really understand, we appear to have evoked—from those who normally shun everything technical—a feeling for aviation and spaceflight.

Like most educators, however, we realize that we do not yet know where to begin to exploit that appeal. The answer may lie in the most important yet least understood tool of learning: the brain. Currently, far too little is understood about how the brain functions. One area of research that continues to challenge scientists is the differences in function between the right and left hemispheres. For instance, researchers now know that the right hemisphere controls musical ability, as well as a feeling for the tone or emotion intended. The left hemisphere, in contrast, deals in analytical terms, understanding the meaning of a phrase but not the tone.

When one hemisphere of the brain is damaged, the individual suffers a corresponding loss of ability. He or she may be re-educated through training of the other hemisphere, but frequently that is possible only in very young children. For some functions, full redevelopment is possible only when the training starts before the child is two years old. Does that mean that our educational efforts should begin at an earlier age?

For more than a decade, leading scientists have tried to formulate curricula for university courses with such titles as "Physics for Poets." So far, most poets have remained impervious; a course on poetry for physicists might well prove to be a similar failure. Is it possible that we are approaching the problem at the wrong level, attempting to teach students far too late in their development?

We need to research such questions along fundamental lines to find the answers. Snow realized that the only way our society can reach rational decisions about its future is by teaching each student to think in both humanistic and technological ways. The technical problems that loom ahead will have to be viewed quantitatively. But a conception of life in the next generation might well be described best in works of fiction. Some of this century's most provocative forecasts were novels by such authors as H.G. Wells and Jules Verne.

The major questions our society will face in the century ahead will require both analytical and lyrical forms of thinking. Our success or failure in bridging the two cultures will no doubt affect the world we pass on to our children.

—Martin Harwit is the director of the National Air and Space Museum.

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Letters

Beyond Apollo

Congratulations on your excellent Apollo issue (June/July 1989). You dug up facts and figures that I haven't seen anywhere else. I was especially intrigued by Andrew Chaikin's "Why Haven't We Gone Back?" One thing that has continually puzzled me is the status of Apollo engineering blueprints and tooling. Some people suggest that the contractors, seeing the end of the Apollo program and sensing its replacement, destroyed the tooling and blueprints. Now some say we should consider using Apollo command module technology for space station *Freedom*'s Assured Crew Return Capability, but it seems that we have indeed lost some critical technology. The same holds true for the development of a heavy-lift, Saturn-class booster.

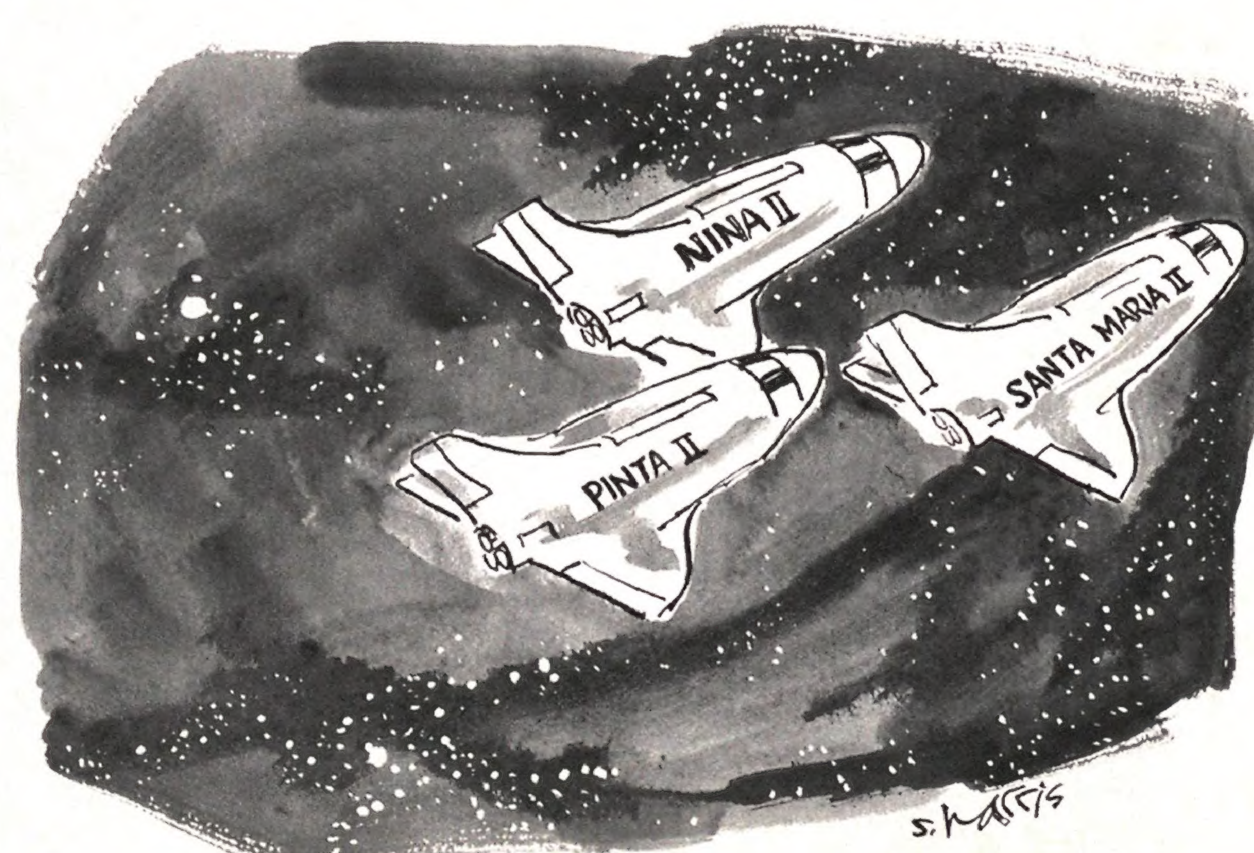
Ernest W. Maurer
Huntington Beach, California

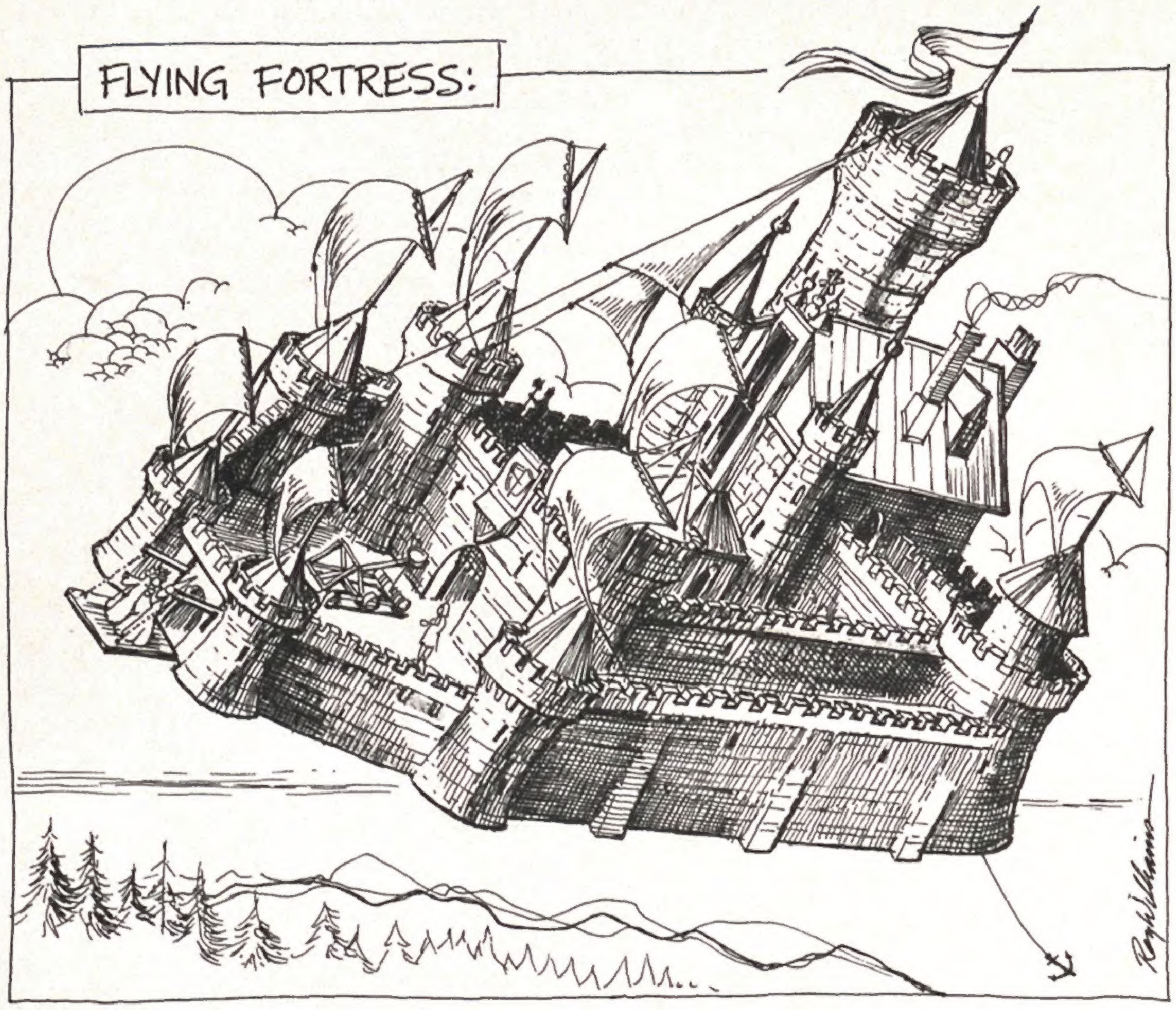
Although at 15 I am too young to remember the Apollo years, after reading the June/July 1989 issue I feel as though I lived through every moment of it, and I also gained new respect for those who made Apollo what it was. Why have we let the space program lose momentum since those years? It seems that back then a goal was set and everyone worked toward that goal until it was accomplished. Why can't we see the unity and pride that the Apollo program gave this country and work even harder in supporting the space program today? If it is a clear, defined goal that we need, such as President Kennedy's goal to land a man on the moon, then let's set one.

Jared Whatcott
Kanosh, Utah

"Requiem for a Heavyweight" by T.A. Heppenheimer brought back memories. As a teenager, I could recite a list of statistics on the Saturn V that either bored or amazed friends and family. To me, the Saturn V was a work of art. I even kept a four-foot-tall model of it in my bedroom.

I watched the launches of Apollos 16 and 17 from the Kennedy Space Center. I especially remember the launch of Apollo 17 because it was the only one made at night. I vividly remember the sky pulsating with the light from main engine ignition, and my bell bottom pants fluttering in the





shock wave a minute or so later.

I left the launch site with the image and sensation of the launch etched in my memory. I also departed feeling a little sad, for although there remained one more launch of the Saturn V, I knew the end of an era was at hand.

Tom Zifka
Clermont, Florida

I thought it was determined a few days after the lunar landing that what Neil Armstrong actually said as he stepped off the lunar module and onto the surface of the moon was "That's one small step for *a* man, one giant leap for mankind." The "a" before "man" gives the sentence sense. The initial news reports unfortunately burned the incorrect version into the popular memory. I was disappointed that this was not printed correctly on the otherwise fine poster inserted in your Apollo issue.

Richard S. Lee
Charleston, West Virginia

Editors' reply: You're right that "One small step for man, one giant leap for mankind" doesn't make sense. But the recording of Neil Armstrong's words reveals that the needed "a" never made an appearance on the moon.

In "A Trip to the Moon," it was unfortunate that Kenneth Weaver's explanation of orbital rendezvous made the maneuver seem paradoxical. The difficult part, though in no way paradoxical, is calculating the "burn time" required to generate an intersecting smaller orbit that permits the two objects to come together and dock.

Also unfortunate is that the first U.S. attempt to link up in orbit had to be aborted because NASA had overlooked such a basic concept and wasted too much fuel "chasing" by accelerating toward the target.

John Grygo
Cowlesville, New York

"Full-Court Press: Apollo Meets the Media" brought back many fond memories of the days when I captioned Apollo mission photographs for a cooperative still-photo pool NASA operated for wire services and magazines.

The section by Ralph Morse, who produced some of the space program's most interesting photos, was typically Ralph. I always enjoyed it when he explained how he set up a particular shot, so I in turn could convey highlights in my captions. I used to think that Ralph's set-ups were more complicated than some space activities.

Another contributor to the article, Howard Benedict, also helped me a great deal when I joined the Cape Canaveral press corps. No matter how busy he was, Howard always had time to help me and other reporters put into perspective events taking place at one of the world's most exciting datelines. In my opinion, his recent space-related articles are as fresh and interesting as those he wrote when our space program was in its infancy.

Steve Milner
Newport News, Virginia

In the history of Tang on page 40, I believe you gave credit to the wrong "General." General Foods makes the drink mix, not General Mills.

John R. Warmbrod
Knox, Pennsylvania

I still recall my father telling me to stay awake and watch Neil Armstrong's historical first step on the moon. As a child growing up in the 1970s, I watched all of the Apollo moonwalks and dreamed of becoming an astronaut.

I am now a third grade teacher, and I participate in what I believe to be the best loan program available. For a period of two weeks NASA sends me a lunar sample disk, which contains soil and rocks collected during the Apollo 15, 16, and 17 missions. But while the students enjoy seeing the disk, they cannot experience the excitement that we used to feel during the lunar missions, even when they watch films about Apollo. It's impossible to explain to them the feelings from that time and the worldwide celebration of Armstrong's first step on the moon.

The lunar sample program does let me share the past with our future. I hope that the future includes space travel to Mars and other planets.

Leslie N. Herschler
Garden Grove, California

Function, Not Form

In "Hell-Bent for Leather" (April/May 1989) the writers state that civilians buy leather jackets "simply because they look cool." That may apply to some people, but as a post-World War II veteran I would like to state that I own two replicas because they are comfortable and durable and because they breathe. The same cannot be said of the nylon jackets issued to me by the Air Force.

Howard V. Scotland Jr.
Lutherville, Maryland

An Inside View

I would like to point out a slight problem in "Snapshot" (Above & Beyond, June/July 1989). Although driver Glendinning did indeed display great visual acuity in catching the fly spot on the Vulcan left wing, his skill is nothing compared with the X-ray vision of Air Vice Marshal Ron Dick,

who saw "pistons flashing in the sun." The pistons would have been in the cylinders, surrounded by a considerable thickness of steel cylinder walls.

Harold J. Read
Englewood, Florida

Author's reply: It just goes to show that you should never allow a professional airman to hold forth on mechanical objects other than airplanes. It may be that the name Kingston Flyer *misled me into thinking that this vehicle was something I could understand. It would appear, however, that I got my pistons mixed up with my connecting rods.*

Chairmen of History

I read "Chariots of Fire" (April/May 1989) with great interest since escape systems have been my profession for the past dozen or so years. I found it very informative; however, I wish that the author had mentioned the pioneering work done by Fred Stencel and the company he founded, Stencel Aero Engineering Corp., in the early 1950s. I joined that company, located in Asheville, North Carolina, in 1978, where we designed, tested, and built ejection seats for the Marines' AV-8B and TAV-8A Harriers, the German and Nigerian Alpha Jets, the Navy's A-7s, and other airplanes. I estimate that we have produced some 1,000 escape systems.

In 1986 the Stencel company was absorbed into the Universal Propulsion Company and a cadre of skilled people was relocated to the Universal facility in Phoenix, where we are continuing the work begun by Fred Stencel. We are proud of our accomplishments and will continue to build upon the work we have done.

F. Donald Wilson
New River, Arizona

To my knowledge, work was being done in the United States on ejection seats earlier than 1944, the date given in "Chariots of Fire." I was at Boeing in 1942, and I remember a contract being completed for a number of Douglas A-20 fighter-bombers later known as Boston Night Fighters.

My shop supplied some needed tooling, and I became familiar with a problem in the ejection seat canopy. It was supposed to open before the seat ejected but some didn't. A suggestion that all pilots wear cowboy hats to protect their ears was rejected out of hand.

It was later discovered that the canopy varied because of a rivalry between the assembly shop's first and second shifts. Each shift had designed and built its own assembly jig. Each locked up its jig so the other couldn't use it. Finally an airplane came down the line with a small bag tied to the canopy and a red sign reading "For emergency use only." Oddly enough, no one questioned it until a government inspector with no sense of humor opened the bag at final inspection—and blew his stack. Inside was a can opener.

W.S. Vickerman
Ellensburg, Washington

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Push-Button Docking

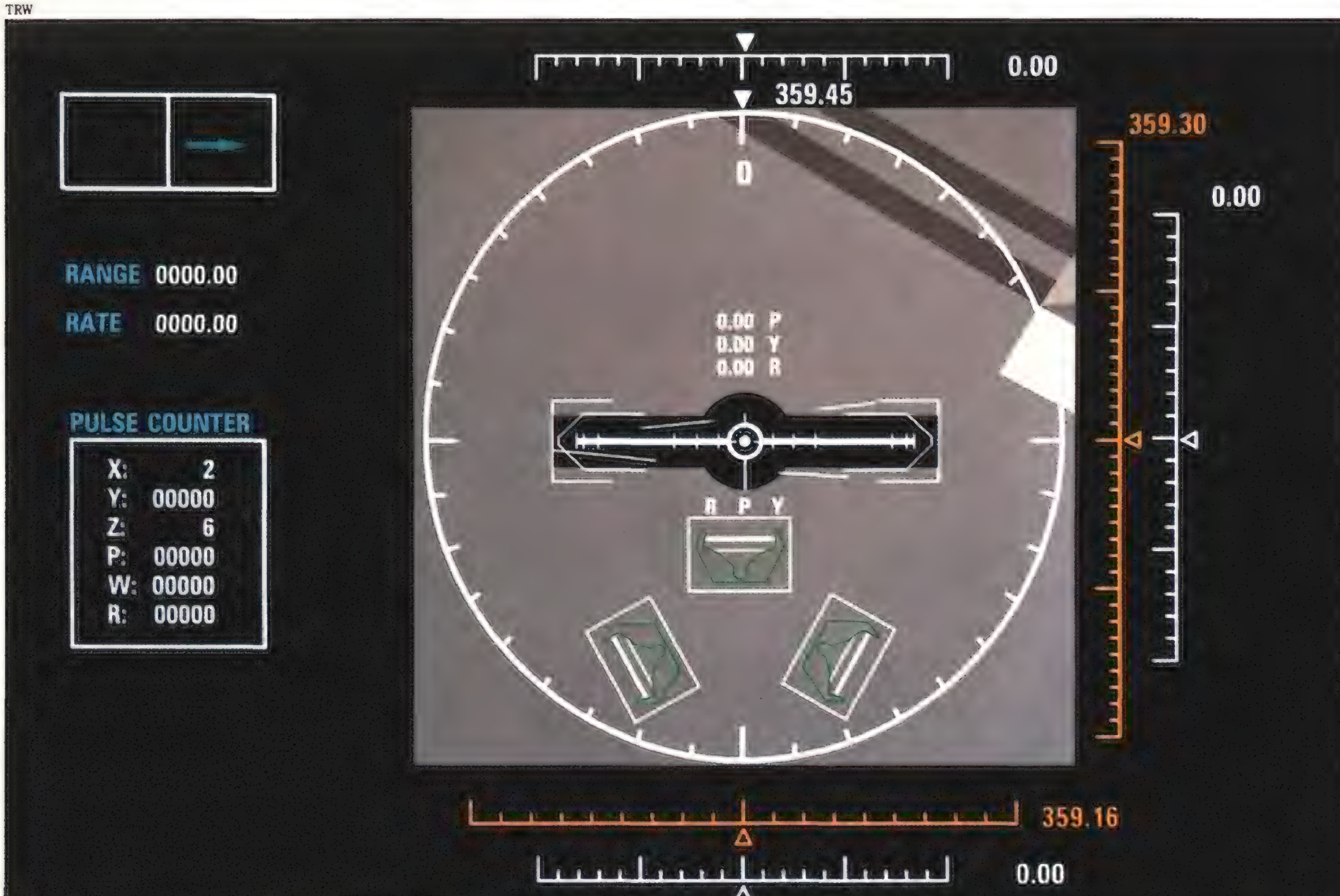
I am the holder of an OMV PhD, conferred on me by TRW. This, according to the TRW certificate, means that I am a Pretty Hot Docker of the Orbital Maneuvering Vehicle—at least the video image of the OMV, which I pretty hotly docked with a video image of the Hubble Space Telescope by pumping a joystick and punching buttons. It wasn't hard to do—TRW project engineer Keith Cok sat next to me at the console and told me every move to make. But I got the certificate anyway.

Had this been a real docking, each pump of the joystick would have fired several of 58 small thrusters mounted in four modules on the rim of the OMV, a five-foot-high, 15-foot-wide spacecraft about the size and shape of an above-ground plastic swimming pool. Once the OMV had crept into proper position, its three mechanical claws would have grabbed three handles, or trunnions, on the telescope and carried it, like Superman rescuing Lois Lane, back to a safer orbit.

The real OMV will undertake its first mission sometime after 1993, when it reboosts the Hubble telescope after drag created by solar radiation causes its orbit to decay. The OMV will also carry satellites from low to higher orbits, retrieve them for refueling or repair, tug them into a reentry position so their debris will fall in an ocean, and nudge pieces of the space station into place. For these tasks the OMV will be maneuvered by astronauts on the ground at a Johnson Space Center console. (When the space station is complete, there will be a console there, too.)

Deployed from the space shuttle, the tug will be propelled by four throttle-controlled engines to the target's orbit. (The engines are smaller versions of TRW's Apollo Lunar Module Descent Engine, which lowered the astronauts to the surface of the moon.) The OMV will use its own guidance and control system to fly within a thousand feet of its target, but at the current level of sophistication in autonomous systems,

TRW



rendezvous and docking will have to be controlled from the ground with the help of a communications satellite network, radar, and on-board cameras for precision maneuvers.

No sweat. I've done it. During my session the space telescope came into view on the lower of two video screens on the console. Cok told me to pump the joystick six times. This did not exactly send the OMV zooming toward the telescope—pretty hot dockers approach gradually and then slow down to a docking speed of only 0.05 feet per second or less.

I watched the target grow slowly until it filled the lower screen. Cok was calm, and nothing flashed in the box marked CAUTION/WARNINGS on the upper screen. One event it could have warned me about is a handoff from one communications satellite to another, during which the docker loses contact with the OMV for up to a minute—enough time, Cok noted from having watched some of the astronauts' simulator training, for the nine-ton OMV to plow into the $1.5 billion space telescope.

Magically, my OMV was in precise attitude alignment with the space telescope. If it hadn't been, I would have used several of the thrusters to reposition it. The use of the thrusters grows considerably more complicated if the target is spinning or tumbling. Mine wasn't.

A white bar at the center of the screen gradually filled the rangefinder, and three small claws, representing those on the OMV, appeared below it. When all three changed color, indicating that a telescope trunnion had entered each one, I pushed the button Cok indicated and clamped those babies shut. Mission accomplished.

Six astronauts have used the OMV simulator to test the "man-machine interface." TRW will study their responses and make any necessary revisions to the prototype before it reaches a stage called the "critical design review" this fall. Astronaut Rick Hieb says his group considered whether the claws on the OMV should be controlled by a button on the console or on the joystick. I think I could handle either one.

—Linda Shiner

Berlin, Marseilles, Ploesti, Fort Worth

On a warm Sunday last May, Main Street Plaza in downtown Fort Worth, Texas, was crowded with teenagers participating in a charity walkathon. But on a plot of grass off to one side, small groups of older men posed for snapshots behind a modest wreath with a dozen crimson carnations scattered beneath it. Occasionally a youngster asked what the flowers were for. "They commemorate our fallen comrades," came the reply. "Were there 12 of them?" "No, there were 6,500. We all flew B-24s in World War II, and we lost more than 6,000 just in the Second Air Division."

For two generations of Americans, the second world war is the stuff of PBS documentaries, and the aircraft that flew in it are museum pieces. But for the men who had come to Fort Worth for the 50th anniversary of the B-24 Liberator's first flight, the thick-bellied bomber calls up the most intense experiences and closest friendships of their lives.

Consolidated, now part of General Dynamics, built some 18,000 Liberators in the early 1940s, a production figure that outstripped that of any other U.S. World War II combat aircraft. The long-range bomber served in every theater of combat.

More than 5,000 Liberator veterans came to the reunion, which was sponsored by the International B-24 Liberator Club of San Diego. They attended a symposium entitled "The B-24 at War" and danced to 1940s tunes played by Tex Beneke's orchestra. But for most, the gathering was a time to honor those who returned from the war and remember those who did not. Pilots looked for navigators, radiomen for gunners. Some succeeded, but pilots who were 30 then are now pushing 80, and time is thinning the ranks.

"To hear us tell it, it's amazing the war wasn't over in 30 minutes," says Duke Mazerov of Pittsburgh, a former B-24 pilot in the 445th Bombardment Group. "The sky wasn't big enough for us. We were all squadron commanders." Mazerov and his companions, pilot Sheldon Kling and tail gunner Ed Roloff, confessed that far from being aces, they were just scared kids. There was nothing fun or romantic about a bombing run, particularly in an airplane that handled poorly at 20,000 feet. A six-hour mission could take an additional two hours simply to "form up" before departing for the target—some flights comprised 2,000 fighters and bombers in a 200-mile-long swath. Uniforms were electrically heated, but the frigid air in the unpressurized fuselage froze the blood on the wounded and the sweat on the crews.

The missions are remembered as cities—Berlin, Hamburg, Nice, Marseilles, Ploesti—and the cities by the intensity of enemy fighters and anti-aircraft fire. The callow pilots, bombardiers, and gunners often watched helplessly as the airplane next to theirs was shot out of the sky. On September 27, 1944, 37 Liberators departed a base near London to lead a mission bound for Kassel, Germany. Only seven made it back to the base.

"The war made you bitter," says Harold Fritzler, who at 20 was a B-24 navigator. "In some ways, when you got back, other things didn't faze you much. We thought we'd seen most everything. But now, you've got to forgive and forget."

Like many of his fellow veterans, the soft-spoken Fritzler appeared to have forgiven but not forgotten. As he sat on a park bench in the plaza, he quietly answered the questions of a girl for whom World War II and the Gettysburg address were equally remote. Occasionally a small smile crossed his face.

—Byron Harris

Update

Black Box Upgrade

Nearly all major U.S. airliners now carry digital flight recorders rather than outdated foil tape "scratch" recorders ("The Black Box," June/July 1988). Last May was the deadline for upgrading to the digital unit, which records a dozen or more flight parameters with better reliability than its predecessors.

Big MAC Attack

Clouds lumbered across the North Carolina sky as the paratroopers, judges, reporters, and photographers who were scattered over a broad, sandy rise waited for the next drop. Some lay on truck hoods, some etched swaths in the sand with polished black boots. Occasionally a hand-held radio crackled. "Here comes another one," a paratrooper shouted, lowering his binoculars and pointing to the east.

Three specks on the horizon grew into a Lockheed C-130 Hercules and two T-34C Mentor chase planes swooping in low over Holland Drop Zone. At 800 feet and downwind of the green smoke that marked the target, 21 jumpers exited the C-130, legs bicycling to untwist the parachute risers. "Nice and easy," breathed a paratrooper on the ground, encouraging his peers.

The occasion was Airlift Rodeo '89, and a sprained ankle or two among the cowboys was the norm. The week-long event, held last spring at Pope Air Force Base, gave the U.S. Air Force Military Airlift Command a chance to show off its skill in heavy transport, airlift, and airdrop capability and hone its combat readiness in competitions between MAC units and international teams.

During the second week of June, Lockheed C-141 Starlifters, C-5 Galaxies, and C-130s thundered in and out of Pope and over the base's drop zones, depositing troops and heavy equipment within yards of the sandy target zones. Off the approach end of Pope's runway, combat patrol teams armed with laser simulators negotiated a 30-minute course that was booby-trapped with trip wires and mechanical snipers. C-130s demonstrated "assault landings" on a dirt runway at nearby Fort Bragg, while the larger C-141s made spot landings at Pope. Aircraft maintenance and cargo teams competed in aircraft turnaround matches—refueling, on- and off-loading cargo, finding planted malfunctions in parachute riggings, and performing safety inspections.

The high point of the week—the Big Drop—came on Wednesday, June 7. At noon, military families, top brass, and the occasional civilian gathered at Fort Bragg's Sicily Drop Zone while a C-5B loaded up at Pope with four 42,000-pound tanks and 73 paratroopers. Secretary of Transportation Samuel Skinner was dropped off by an Army helicopter that sandblasted the grandstand audience. Artillery thumped sporadically in the distance, and broad curtains of rain began to close in.

At 1:15 an Air Force officer announced the impending arrival of the C-5 at Sicily and noted that the Galaxy was carrying a record airdrop load of 190,346 pounds, equivalent to that of five C-130s or C-141s. The audience hushed as the C-5 leveled off at about 1,500 feet and started its run.

One tank emerged, then another, a cluster of six parachutes blossoming over each. Two more appeared and drifted gently to the sand. The crowd cheered and hooted with delight as the C-5 climbed out and swung around for its troop drop. The announcer gave the strike report: the first tank was within 130 yards of the target.

There was more applause, and the paratroopers began their exit, creating a neat line of 73 parachutes stitched across the darkening sky. By the time the caravan had packed up and headed back to the base, it was teeming rain.

A C-141 from Andrews Air Force Base was waiting at the terminal to take Skinner and a few Air Force officers and reporters back to Washington. It was also waiting for its pilot—MAC commander-in-chief General Duane Cassidy. ("He's just like the rest of us," a major confided, "big kids who love to fly airplanes.") Once airborne, Skinner and the rest of the passengers rattled around the long fuselage like a handful of loose change. Up on the flight deck, the general contemplated the ragged clouds and patches of blue sky at 19,000 feet. He looked like a man who'd had an exceptionally good day.

—*Patricia Trenner*

COURTESY AEROSPATIALE

All dressed up with no place to go, the first pre-production Concorde, repainted by students and alumni of l'Ecole des Beaux Arts in Toulouse, France, was a stately decoration at March 2 ceremonies there honoring the 20th anniversary of the Concorde's first flight. Thirteen of the Mach 2 airliners are still flying with British Airways and Air France. Under discussion is a Super Concorde with twice the range and passenger capacity of the current version.

Update

Cosmic Dust Clues

A group of U.S. astronomers say they can distinguish the source of cosmic dust by determining the temperature the microscopic particles reached during atmospheric entry ("The Curator of Cosmic Dust," April/May 1987). It is presumed that particles from comets, which contain chemical information on the evolution of the outer solar system, enter Earth's atmosphere at higher speeds and achieve a higher temperature than particles from asteroids, which hold clues to the development of the inner solar system.

SCIENCE/SCOPE®

Artificial intelligence (AI) techniques have reduced fault-location time by 94 percent in the testing of complex infrared sensors during assembly. Working with a detector design, manufacturing expert, and actual test data, Hughes Aircraft Company has developed a set of rules and procedures for an expert system called Coldfinger. It correctly detected and located six types of problems in an infrared sensor containing 160 detector elements and complex processing electronics. One set of defects took a human expert 30 minutes to define, but was identified by Coldfinger in just two minutes. Hughes is also developing AI systems for autonomous land and underwater vehicles, and diagnostic techniques for other manufacturing operations.

A new fiber-optic modem is the first non-cryptographic communications security product to be endorsed by the U.S. National Security Agency. It is approved for the protection of all levels of classified data. The FAM-131 modem is part of an intrusion detection optical communications system (IDOCS), developed by Hughes, that operates on the principle of alarmed fiber optics rather than conventional encryption. With no encryption signal to interfere with the data stream, the IDOCS provides high signal transparency, and can operate up to 13 megabits per second. An additional benefit is the elimination of crypto key management. IDOCS is intended for use between buildings in campus-like environments and local area networks for various applications including command and control and information management.

A new process dramatically reduces Printed Wiring Board (PWB) manufacturing time. The process, called Just-In-Time, helped trim the time to manufacture PWBs at Hughes from four or five months to just ten days. Just-In-Time reduces the cycle times, the time a product spends moving or waiting, by organizing the work flow so everything progresses in unison. Work is planned so that each PWB operation is completed as the next operation finishes its work and is ready to take on the next assignment. All job hardware arrives just in time for the next work to begin on it. Many manufacturing areas at Hughes have adopted similar systems to shorten cycle times.

An advanced computer-controlled system provides radar detection and tracking of all aircraft approaching Japan's borders. The sophisticated defense system, designated the Base Air Defense Ground Environment Extension and the result of a joint development effort between Nippon Electric Corporation (NEC) and Hughes, is proving to be an excellent high-technology system for protecting Japan's borders and sea lines. Should unidentified aircraft be spotted, operators inside command centers can direct fighter interceptors to visually identify the aircraft or take necessary defensive actions. Hughes built Japan's initial automated air defense system in the 1960s.

Hughes Technical Services Company (HTSC™), a subsidiary of Hughes Aircraft Company, is rapidly expanding its contractor operations and logistics support to meet individual and customer program requirements. Upcoming military contracts to be supported by HTSC include simulators for the T-45 Goshawk, Fleet ASW Team Training and Landing Craft Air Cushion. HTSC presently needs engineers, programmers and field service technicians with experience in simulation in order to keep pace with new contract requirements. Qualified candidates may send resumes to: Hughes Technical Services Company, Trainer Support, Dept. S4, P.O. Box 90962, Long Beach, CA 90809. Equal opportunity employer. Proof of U.S. citizenship required.

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HUGHES

Subsidiary of GM Hughes Electronics

Paris Chocolates is flight testing its new Flyer candy bars in New England gourmet shops and the National Air and Space Museum gift shop. Included with every bar is a card with a sentence or two on aviation trivia and history.

Update

Auroras in the Lab

Scientists at the Georgia Institute of Technology have created miniature auroras in a vacuum chamber ("The Aurora Patrol," February/March 1989). Georgia Tech researcher Michael Hayes says the man-made version of the upper atmospheric phenomenon may provide data at a fraction of the cost of the sounding rockets and satellites currently used to study the aurora.

Open Mouth, Insert Foot

An AV-8B Harrier had just crashed and burned, and Dave Ganger was in the hot seat. "Tell me what was going on when the plane went down," a TV reporter demanded, thrusting a microphone in his face. Ganger, the aviation safety officer at the Naval Weapons Center in China Lake, California, began with basics but soon went off on a tangent. By the time the interview ended he was chatting about the experimental infrared goggles the pilot was wearing.

When the minicam stopped rolling, Ganger's expression went from solemn to sheepish as the interviewer critiqued his performance. "Remember," she said, "agenda, agenda, agenda . . . you are trying to present *your* agenda, not the reporter's. If you don't want to hear yourself saying something on the radio or see yourself on TV, don't say it in the first place."

Joy Nuell should know. Having spent some 15 years as a TV and radio reporter, she now trains potential interview subjects to meet the press. "Today we're going to learn about dealing with them effectively and holding them off effectively," she told her students at a Communications for Aviation Management seminar offered by the University of Southern California last May. The class was devoted to improving communication—not only with the press but between bosses and underlings, air traffic controllers and pilots, and pilots and crew members.

The most revealing stories about the critical role communication plays in aviation came not from the instructors but from the students. In the session devoted to resolving conflict, Bill Doss, chief accident investigator for the Pan American chapter of the Airline Pilots Association, recalled how a communication failure caused the 1977 Tenerife disaster in the Canary Islands. According to Doss, the KLM 747 captain failed to heed the objections of his crew—or the crew failed to convince the captain of the danger—and began a takeoff roll despite the fact that a Pan Am 747 was taxiing down the runway. The collision set off an inferno that killed 582 people.

The liveliest session at the seminar was the one devoted to the media, a group the students seem to put on a level with child molesters. Nuell pointed out that the reporter-subject relationship isn't always adversarial. "I maintain that most reporters arrive at the scene of a story just wanting information," she said. "But if you want to participate in your own demise, they'll be very cooperative."

Rayner Hutchison III, head of aeronautical engineering at Hughes Aircraft, learned this about 10 years ago when the pilot of a Cessna Cardinal made an emergency landing on a grass highway median strip. Angered when reporters began badgering the pilot, Hutchison spirited him off the scene and stormed back to tell the media what he thought of their tactics. "Guess who made the news that night?" he asked ruefully. Next time, he and his classmates will know better.

—*Preston Lerner*

Update

Spreading the Word

Last spring NASA used a commercial satellite to relay verbal communications between a Boeing 727 over the eastern seaboard and a ground station in Connecticut. The test was a major step in a Jet Propulsion Laboratory study of a mobile satellite communication system for areas not served by cellular systems, including maritime, aeronautical, and remote-location ground users ("Down to the Sea with Satellites," June/July 1987).

Anniversaries . . .

1783
September 19 A sheep, a duck, and a rooster become the world's first aerial passengers. Before a crowd of thousands that included Louis XVI and Marie Antoinette, Jacques and Joseph Montgolfier inflated a 57-foot-high balloon with smoke from a fire fed by wet straw, old shoes, and

BETTMANN ARCHIVE

The launch of three farm animals in 1783 drew both peasants and royalty.

decomposing meat. Although the stench caused the royal spectators to hasten their inspection of the furnace area, all were on hand to watch the balloon rise 1,450 feet before descending toward a forest two miles away. Suspended from the balloon in a wicker cage, the animals were unharmed by the flight.

1877
August 11 Asaph Hall discovers one of Mars' two moons using the U.S. Naval Observatory's new 26-inch refractor telescope. Hall nearly abandoned his search

ASTRONOMICAL SOCIETY OF THE PACIFIC

Mars' bright glare almost kept Asaph Hall from finding its two moons.

after being frustrated by the bright Martian glare, but his wife urged him to persevere. At 2:30 a.m. on August 11, the astronomer noticed a tiny object that looked promising, but the skies soon clouded over; five nights later Hall determined the speck of light to be a moon. The next night, he spotted Mars' second satellite. Hall named the moons Deimos and Phobos.

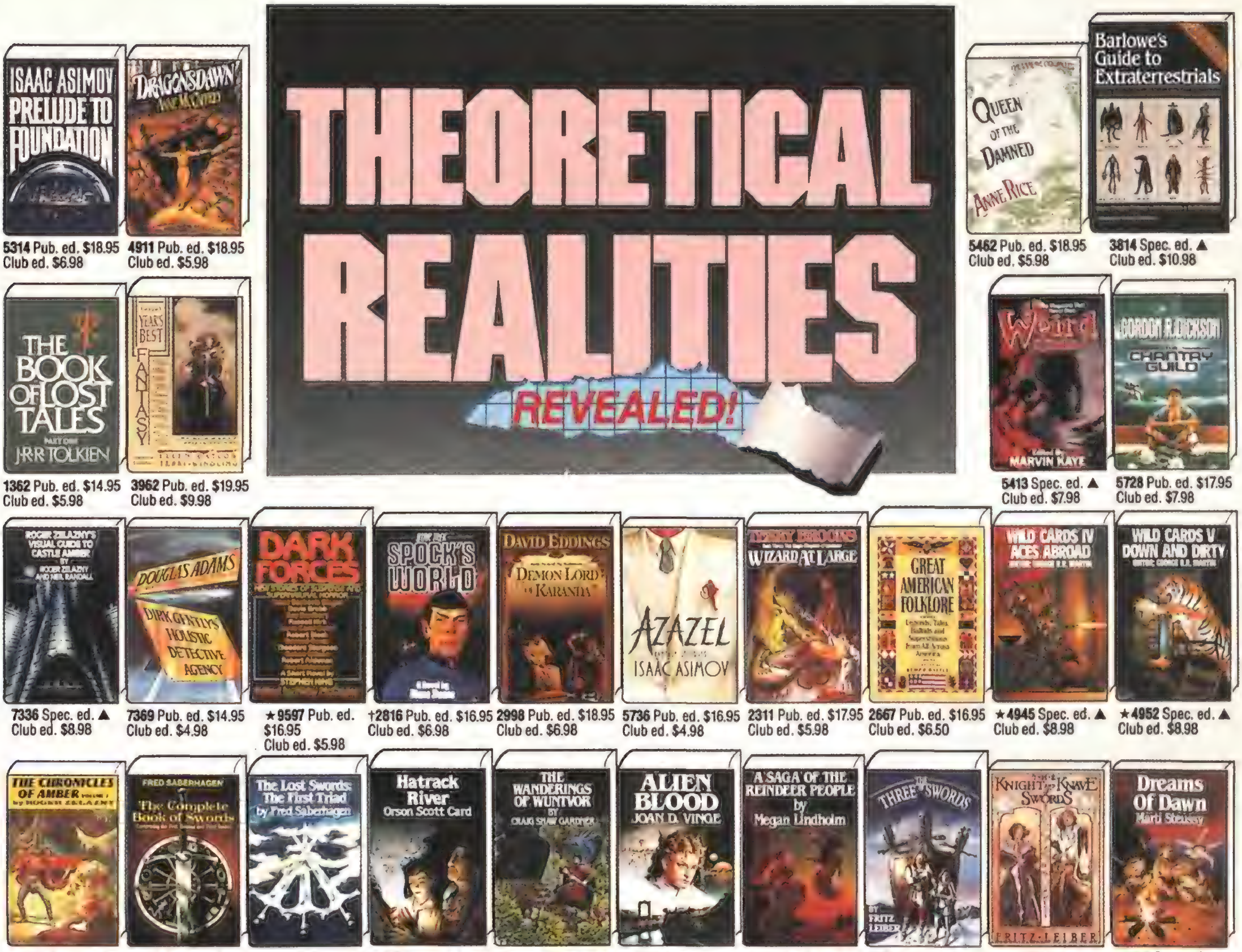
1920
September 15 Major H.A. Strauss, commander of an Army C-4 dirigible on its way to California from Virginia, makes a detour over Cincinnati, Ohio, to deliver a gift. Strauss made two tight circles over a residential area before dropping a bouquet of flowers to his mother as she waited on her lawn.

1922
September 4 Army lieutenant James H. Doolittle becomes the first to fly across the United States in less than 24 hours. At 10 p.m. Doolittle began his 2,200-mile trip from Pablo Beach in Jacksonville, Florida, and stopped the next morning in San Antonio, Texas, to refuel. By nightfall, Doolittle had landed his specially built de Havilland DH-4 at Rockwell Field in San Diego, California. He reported feeling drowsy just once, about two hours out of Jacksonville. "I thought how fine everything was and how pretty the motor was running," he said, "and then I became wide awake immediately and was not bothered again."

NASM

In 1922 Jimmy Doolittle flew coast to coast faster than anyone before him.

1925
August 14 Seventeen-year-old Jack Richman hitches a three-hour ride on the wing of a California National Guard airplane flying from Las Vegas to Los Angeles. Shortly after takeoff, the pilot, Major C.C. Moseley, noticed a heavy drag on one wing. "As I live, there was a boy's head sticking up over the end of the wing. I never had such a shock." Richman and a friend had traveled from Milwaukee to Las Vegas via train, "but they was [*sic*] so many bulls around that we had to get out," said the stowaway. When Richman noticed Moseley starting his airplane, he ran out and grabbed onto the underside of one wing. Said Richman, "I got pretty dizzy and kinda sick, but I hung on. Then I got up on the wing and kept on stickin' on and got here. That's about all there was to it."



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04-SF49

1934
September 28 After eight years in operation, the German airline Lufthansa issues its one millionth passenger ticket. The traveler, who was flying from Munich to Berlin, received a picture of Adolf Hitler upon landing.

1936
September 2 Eastern Airlines pilot Dick Merrill and Broadway entertainer Harry Richman leave New York's Floyd Bennett Field on a round-trip transatlantic flight. Flying *Lady Peace,* a Vultee monoplane filled with Ping-Pong balls for buoyancy, they lost their bearings over the Irish Sea and landed in a cow pasture in Wales, far short of London, their destination. On the return trip, inclement weather forced Merrill and Richman to land in a bog in Musgrave Harbour, Newfoundland. It took days to dig out the airplane and move it to a small strip of beach. During takeoff, *Lady Peace* nearly mowed down several bystanders, who dove into the surf and dropped to the ground to avoid the oncoming wings. Witnessing the takeoff, Eastern Airlines president Eddie Rickenbacker said he almost "died of heart failure." When Merrill and Richman finally landed at Floyd Bennett Field, their airplane again became mired when it rolled off the runway.

1937
August 17 At an annual Soviet air display, a formation of 48 airplanes spells out Stalin's name in the sky. Two other groups of airplanes formed Lenin's name and a red star.

1962
September 5 A Milwaukee astronomer observes the Soviet satellite Sputnik 4 reentering the atmosphere over the midwestern United States shortly before 5 a.m. His sighting coincided with reports of UFOs in the pre-dawn sky of Nebraska, Minnesota, and Wisconsin. One week later, United Nations representative Francis Plimpton exhibited a 14-pound chunk of steel that had dropped onto the pavement in Manitowoc, Wisconsin. Said Plimpton, "Fortunately, the fragment here caused no serious damage or impact, but the possibilities of harm are evident."

A bird strike brought down the Air Force's most advanced operational bomber.


ROCKWELL

September 23 ABC premieres "The Jetsons," an animated cartoon produced by Hanna-Barbera. Set on Earth in the 21st century, the series depicted the daily lives of George Jetson, an employee of Spacely Space Sprockets, his wife Jane, children Judy and Elroy, and space dog Astro. Universal Pictures has recently announced that it will release a feature film of the Jetsons this December.

HANNA-BARBERA

The Jetsons were a typical 21st century nuclear family.

1984
August 27 In a campaign speech at a Washington, D.C. junior high school, President Reagan announces that a teacher will be the first U.S. non-astronaut passenger in space. Chosen by NASA in 1985, Christa McAuliffe, a high school teacher from Concord, New Hampshire, died aboard the space shuttle *Challenger* on January 28, 1986.

1987
September 28 An Air Force B-1B bomber flying a high-speed, low-altitude training mission crashes near La Junta, Colorado, after colliding with a large pelican. Immediately after the bird strike, the B-1B ascended from 600 feet to 3,500 feet, allowing three crew members to eject safely; three other men died in the crash when they did not have time to bail out. The B-1B is designed to elude enemy radar by flying low and fast, but these mission requirements make it particularly vulnerable to bird strikes. "If you track bird populations around the world, we do have a problem," said Brigadier General James W. Meier. "The mass of that bird is like a bowling ball operating at the speed of sound."

. . . and Events

August 8–13
Airshow Canada. International aerospace symposia, tradeshow, and film festival. For the first time, the Soviets will bring a MiG-29 fighter to North America. At Abbotsford Airport and Vancouver Trade and Convention Center, Vancouver, British Columbia, Canada, (604) 852-4600.

August 19 & 20
AeroFest. Blue Angels and Golden Knights. At Reading Municipal Airport, Reading, PA, (215) 372-4666.

1941 "Wings of Eagles" Airshow. B-17s, B-24s, and other World War II aircraft. At National Warplane Museum, Geneseo, NY, (716) 243-0690.

August 24–27
Sentimental Journey to Cub Haven Fly-In. At William T. Piper Memorial Airport, Lock Haven, PA, (717) 893-4207.

August 25
Voyager 2, traveling within the solar system since 1977, will make a flyby of Neptune, passing 3,000 miles over the cloudtops at the planet's north pole at midnight EDT.

September 9 & 10
Mid-Eastern Regional Fly-In. World War II aircraft and homebuilts. At Marion, OH, (513) 849-9455.

September 16 & 17
Superbatics '89, the Great Kansas Airshow. Blue Angels and World War II aircraft. At Forbes Field, Topeka, KS, (913) 862-3303.

September 23 & 24
19th Experimental Aircraft Association East Coast Fly-In. Flea market, pancake breakfast, and an appearance by August Bellanca. At Greater Wilmington Airport, Wilmington, DE, (301) 942-3309.

September 30 & October 1
Open Cockpit Weekend. Sixteen aircraft open for inspection. At New England Air Museum, Bradley International Airport, Windsor Locks, CT, (203) 623-3305.

Organizations wishing to have events published in Calendar should submit them four months in advance to Calendar, Air & Space/Smithsonian, *370 L'Enfant Promenade SW, 10th Floor, Washington, DC 20024. Events will be listed as space allows.*

—Diane Tedeschi

Back to the Futurists

We will sing of . . . the sleek flight of planes whose propellers flap in the wind like banners and seem to clap like an enthusiastic crowd.

—F.T. Marinetti
Futurist Manifesto, 1909

MUSEO AERONAUTICO CAPRONI DI TALIEDO, ROME

Mussolini tried to exploit Futurism's aerial imagery, as depicted in Bruno Munari's 1936 collage "We Shall Then Go in Search of a Female Airplane."

Hoping to set in motion a 20th century Renaissance, Italian artists in the early 1900s embraced a new muse: technology. The result was an art movement known as Futurism. Originally the Futurists exalted the automobile. But gradually artists were urged to address "the immense visionary and sensory drama of flight."

The viewpoint from above—a "plane's-eye perspective"—inspired a new sensibility for Filippo Tommaso Marinetti, the father of the Futurists, and artists such as Bruno Munari and Giacomo Balla (who named his daughter Elica, Italian for "propeller"). Works of these and other artists are part of "*Aeropittura Futurista*: Images of Flight in Italian Art from 1913 to 1942," on exhibit at the National Air and Space Museum through mid-September.

Images of wings, propellers, and rooftops dominate the 116 objects on display, most of which have made only a single appearance outside Italy. Paolo Colombo and Gerald Silk, both from the Tyler School of Art of Temple University in Philadelphia, are the guest curators for the exhibit.

The Futurists' infatuation with technology was based on its potential for change. Unfortunately, the original Futurists were equally attracted to war, especially after a 1911 conflict with Turkey, in which Italy became the first country to use airplanes in combat. But after several artists were killed in World War I, war lost its appeal to the Futurists.

In an attempt to recapture its earlier spirit, Futurism began to keep company with Fascism after the war. Their common bond was aviation. Indeed, the Fascist motto was "Italy is being reborn with new wings!" The result, as Silk notes, led to an unusual combination of avant-garde aesthetics and reactionary politics. Viewers can enjoy the work without understanding its context, says gallery curator Mary Henderson, "but you need to know the social, historical, and political background to get its full significance."

Futurism re-emerged in 1929, two years after Lindbergh's transatlantic flight, in a later phase known as Aeropittura Futurista. In a forthcoming book, Silk writes, "In the ambitious, all-embracing spirit of Futurism, a movement claiming to be as committed to changing life as it was to changing art, the 'aero' sensibility spread to other media, including aeropoetry, aerosculpture, aerophotography, aeromusic, aerodance, aerofood, aerial theater, aerial architecture, aerial set-design, and aero-radio-television theater. Marinetti went so far as to speak of 'the aero-life.' "

Futurism finally faded in the 1940s following the demise of Fascism and the death of Marinetti. But it seems appropriate that the work of the artists inspired by the *Spirit of St. Louis* now enjoys an encore in the same museum as Lindbergh's famous airplane. "I think Marinetti would be thrilled to have the exhibit in this museum," Henderson says.

The Labors of Hercules

"Singapore Tower, Herky 460. Request landing instructions," called the pilot of the C-130 Hercules. Only hours earlier Lieutenant Pham Quang Khiem had fled South Vietnam in the stolen aircraft with 56 members of his extended family. They had crossed the South China Sea, and now Khiem wasn't sure what kind of reply he'd get from the control tower. Finally it came: "Herky 460, cleared to land runway 02."

This Lockheed C-130A, which escaped to safety before the fall of Saigon in 1975, was recently selected by the Museum to represent air cargo combat craft in its collection. The new acquisition served 14 years in the U.S. Air Force before it was transferred to the South Vietnamese air force in 1972.

"A big, beautiful doll," is how senior air curator Robert C. Mikesh describes the C-130, even though he admits, "The nose has always bothered me." Affectionately referred to as "trucks" or "trash haulers," more than 1,900 of the sausage-shaped cargo planes have been produced since the C-130 made its maiden flight in 1954. In addition to all of the U.S. services, more than 60 other nations rely on the classic Hercules.

With an ability to haul 92 troops, the C-130 tends to show up where the action is—for instance, the daring Israeli raid to rescue hostages held at Uganda's Entebbe airport in 1976 depended on C-130s. While not as glamorous as the Phantoms or Crusaders that fought in the skies over Vietnam, the C-130 played a major role in that war, where it participated primarily in resupply and bombing missions. The Hercules was also used extensively in the evacuation of cities during the fall of South Vietnam.

This was the case with the Museum's C-130. After witnessing the chaotic evacuation of Da Nang while flying one of the last resupply missions to that city, Khiem remembers thinking, *If that happened here, how can I get my family out?* Khiem, a C-130 pilot for the South Vietnamese air force, made plans to leave Saigon after he saw the evacuation of Americans. He made his escape just 27 days before Saigon fell.

Instead of feeling elated when he landed in Singapore, Khiem felt guilty for not carrying more passengers to freedom. But if word of the escape had leaked, he says, "the whole country would have scrambled to get on my airplane." Now living with his family near Dayton, Ohio, Khiem flies 727s for Piedmont Airlines.

Following its role in Khiem's escape, the C-130 made its way back into the U.S. Air Force inventory and eventually went to a Reserve unit in Milwaukee, where Mikesh found it. The airplane is now in temporary storage at Washington-Dulles International Airport, near Washington, D.C., while the Museum awaits selection of a new facility large enough to exhibit it. Mikesh, who says he was on the edge of his chair when he heard Khiem's story, can't wait for the Museum's visitors to share in the drama. "I can already hear the docent's words . . . ."

Lab Work

From Sputnik to the Hubble Space Telescope, more than a dozen satellites are represented in the Museum. Recently two new ones have been playing an increasingly larger role in the Museum—but not as exhibits. In both cases, the Museum's Laboratory for Astrophysics is actively involved in the research.

The two satellites, the Infrared Space Observatory (ISO) and the Submillimeter Wave Astronomy Satellite (SWAS), are scheduled for 1993 launches. "Before, we just reported after the fact," says Howard Smith, senior astrophysicist and the

With a reputation as a workhorse that will carry anything, anywhere, anytime, the C-130 Hercules lives up to its name. ROBERT C. MIKESH

department's chairman. "Now we're actually in the loop and it gives us a more complete perspective."

Infrared astronomy, one of the lab's areas of concentration, has opened a new era in astronomical exploration by measuring electromagnetic radiation at infrared wavelengths emitted from objects in space. The lab has an active ground-based observational research program, but satellites are necessary because Earth's atmosphere absorbs most infrared energy before it can reach detectors on the ground.

ISO is an international scientific collaboration on a European Space Agency project. The laboratory's new satellite follows in the footsteps of the 1983 Infrared Astronomical Satellite (IRAS), the first astronomy satellite to survey the heavens from above the atmosphere (see "Seeing Red," December 1987/January 1988). Martin Harwit, Museum director and member of the lab staff, describes ISO as "the next major milestone" in infrared astronomy. It will be launched by an Ariane 4 from Kourou, French Guiana, and carry a scientific payload consisting of four instruments: long- and short-wavelength spectrometers, a camera, and an imaging photopolarimeter. The spectrometers will examine atoms and molecules in stars, nebulae and galaxies, and interstellar clouds of dust.

The Museum is also one of a half-dozen members of a team working on SWAS, which is part of NASA's newly revitalized Small Explorer Program. SWAS is more restricted than ISO and will study the longer wavelengths of the electromagnetic energy tucked between infrared and millimeter wavelengths.

ISO will use special metal mesh reflectors developed by the Museum's lab.

ESA

Led by Gary Melnick, an astrophysicist at the Harvard-Smithsonian Center for Astrophysics, the project will study the chemistry of thousands of molecular clouds in the Milky Way and how these clouds collapse to form stars. SWAS will be launched aboard a Scout rocket from the San Marcos Platform off the coast of Kenya.

With its emphasis on molecular clouds, SWAS will map local clouds, such as those in Orion, Taurus, Ophiuchus, and Perseus. It will also perform a survey of galactic giant molecular clouds. Its payload will consist of an antenna, two radiometers, and an acoustic-optic spectrometer.

The lab is enthusiastic about the benefits of its research, not only for the scientific community but for the Museum's visitors as well. "Unless you are actually doing something," says Harwit, "you have a hard time explaining it to 10 million people."

—David Savold

Museum Calendar

Except where noted, no tickets or reservations are required. Call Smithsonian Information at (202) 357-2700 for details.

Planetary Science Exhibit
New images of the planet Neptune transmitted by the Voyager 2 spacecraft will be shown on closed-circuit monitors in the Milestones of Flight Hall and Space Hall in early August, if the quality of transmission is acceptable.

Summer Concert Series
Free concerts on the west terrace featuring music ensembles of the U.S. armed forces. On selected weekdays from 6 to 7 p.m.

August 5
Monthly Sky Lecture: "Is There a 10th Planet?" Robert Harrington, U.S. Naval Observatory. Einstein Planetarium, 9:30 a.m.

September 2
Monthly Sky Lecture: "Voyager 2's Encounter with Neptune." Stanley Cawelti, National Capital Astronomers. Einstein Planetarium, 9:30 a.m.

September 14
New Exhibit in the Sea-Air Operations gallery: "Carrier War in the Pacific." Features models, maps, photographs, and films of six principal carrier battles of World War II: Coral Sea, Midway, Eastern Solomons, Santa Cruz Islands, Philippine Sea, and Leyte Gulf.

Reunion

Your wife calls you an old fool. At age 70 you plan to totter off to Florida to a big, noisy party with a lot of men you don't know. You do this for the sake of meeting up with the handful that flew with you in the good old Such-and-Such Fighter Squadron in New Guinea during World War II.

"When did you last see any of these people?" your wife asks, scanning the list of acceptances.

"I don't know. Forty-something years ago."

"You don't know is right. You don't know anything about them. You only kept up with two of them, and neither one's coming."

"I know them, all right. Some of them are bringing their wives. Why don't you come?"

"I have better things to do. Anyway, I think it's just plain silly."

You have a nagging feeling she's right, but you've already booked a flight and a hotel room in Orlando.

"I wish you were coming," you say on the morning of your flight.

"No, you don't," your wife says. "You'll have a fine time without me. Now get going or you won't make it to the airport two hours early, the way you like."

At the hotel you head for the swimming pool to wait for your squadron mates to return from Disney World or wherever. Finally a couple of old fogies in baseball caps clump to a nearby table. You sidle over and peer at their name tags.

"Hello, Peanut," you say. "Hi, Whale Tail."

They start, and look for your name tag, but you're wearing only a bathing suit. You introduce yourself. "My God," they say. "It's old Fangs!" And so your reunion gets off the ground.

Others show up, many with wives. Once you establish who they are, you begin to recognize them, to see them hazily as they were. You find a corner in a bar where you can move some tables together. You compete to order drinks but your reckless enthusiasm cools when many of yesteryear's boozers now prefer Evian with lemon.

KRISTINE ROBERTS

Conversation becomes feverish, a frantic attack on the sullen earthworks built up by 45 years. When one stumbles in this dash for the past—"Gee, I don't remember that"—the rest of you pick him up and drag him along.

Memories are wrenched into focus. The time Chipper blew a tire on takeoff and groundlooped right in the middle of the strip. "McLean was taking off right after you and you were just sitting there in a cloud of dust. And McLean hauled back and jumped over you and bounced on the other side and got into the air. Remember, Chipper?"

"If you guys remember it too I guess it really happened."

"We blew those goddamn tires all the time. Beast got burned once, didn't you, Beast?"

"Yeah, I hit the ditch when the tire went and a flash burn caught me. I remember they put me in an aid station and I kept trying to get up and get back to my plane."

"Remember old Barney blowing himself out of a latrine? It had just been treated with oil, the way they did, and he was sitting on it and flipped a cigarette into it and went out of there like a mortar shell, right into the creek."

The wives listen with patience and a certain amazement. "You never told me that," one says to her husband. For a moment he looks at her as though he isn't sure of her name. Then the talk picks up again. You try to hear all the stories being told, and then you try to hear just the ones you haven't heard before.

"Logan! That sumbitch led me into a thunderhead over the Owen Stanleys one afternoon and . . . "

"He took out the cartridge boxes and stuffed in gunnysacks of salami and Australian beer . . . "

"Old Deacon got so low he had a coconut jammed in the leading edge . . . "

So the afternoon goes. Dusk falls and one of you, suddenly inspired, starts singing:

A young fighter pilot
to Sydney did crawl,
he'd just come back
from a raid on Rabaul . . .

And the rest of you join in with a roar:

when an old MP sergeant said,
"Pardon me, please:
you've blood on your tunic
and mud on your knees."

A waiter appears in the darkness and says, "Excuse me, gentlemen, but could you keep it down a little? There's a corporate meeting . . . ." How you respond depends on the depth of your sentiment and the extent of your lubrication.

The next day proceeds at a slower pace. You talk about who you are today more than who you were back then. You realize that you and your band of brothers are all about the same height—fighter pilots were generally no taller than five feet ten—and look reasonably fit except for a slight abdominal excess, and that you can probably blame on the war. After 20 months of rotting bully beef and weevily hardtack, most hands swore to never again go hungry.

Some had trouble keeping that pledge. Veterans of your squadron include social dropouts and perpetual failures. The alcoholics among you may have been helped on their way by the war.

Some of you became millionaires—mostly through real estate. Others slipped

into enterprises connected with aviation. Quite a number were Air Force officers, now retired.

The day ends with a cocktail party and banquet where people wander from table to table. You meet men you trained with who joined other squadrons. There is much clapping of backs, hands gripping shoulders.

The group chaplain ends the evening with a reading of the names of those lost in the war. It is dramatic and would be emotional if you let it. But you've gone back to a time when death was just death—not put on exhibition but simply acknowledged with a nod.

"Grimes? He bought the farm on one of the Rabaul missions."

"Felton? Hit the silk about 10 minutes out of Seven Mile Strip and never came back."

"Nedlar? He augured in Milne Bay."

The padre calls for a moment's silence and you bow your head. But tonight, like back then, you can't keep your mind on the dead.

You scrutinize the faces, trying to link them to the ones you saw in the cockpits—taxiing in from a mission, chinstraps and oxygen masks flapping below thin sunburned cheeks, a patina of sweaty dust ending at the curved line etched by the goggles. You try to see them in action, the dark, gray-green or silver aircraft on your wing with these shapes inside the canopies. But you can't make out features—you never could. Just the bulge of the mask, perhaps the raising of a gloved hand. Back in your hotel room, the recollections bring other small things into focus. You find it hard to sleep.

There was the sound of airplanes returning with their guns' muzzle tapes blown off, the open barrels adding a unique shriek to the snarl of the engines. The smoke that fogged the cockpit when you fired everything in the Bell P-39's arsenal. Your eyes stinging, weeping. The way you could spin your head like an owl when you thought an Oscar was on your tail. The rat races when you all tore after one another through the cloud tunnels, rolling inverted, creamy contrails streaming from your wings. Lying in bed, your body twitches and tosses with the memories. Toward morning, you sleep a little, then pack and head for the airport.

Back home, you crawl off to bed at 9 p.m. The phone rings and you hear your wife say, "Yes, he's back, but I don't know how long I can stand him this way. He talks a blue streak, then suddenly gets up and paces, then sits down again. And when I speak to him he jerks his head around like he was being shot at. Honestly . . . "

—*Edwards Park*

The Logbook

Pilot Log, the cover read, in one-inch gold letters. "I'll be damned," I said.

It was the size of a stenographer's notebook, with a black imitation leather cover, and it lay in the bottom of a box, covered with 20 years of dust. I blew away 10 years' worth, sneezed, and opened the book.

The first entry was dated June 12, 1966, and stated that my instructor and I flew from Antioch, California, in a C-172 and spent 1.0 hours doing FAM. A/C, S&L, and TURNS. I remembered what Turns were but was momentarily baffled by the rest of the shorthand. Did the airplane have Family Air Conditioning? Was the mortgage held by a Savings and Loan?

I remembered the Cessna 172. It was yellow, white, and oil-streaked. Like all trainers, it looked sad and student-weary. Then the rest of it came back to me. I had total recall of the airplane because I was required to inspect it minutely, in accordance with Familiarization with Aircraft—FAM. A/C.

S&L stood for Straight and Level flight, a condition impossible to achieve. It doesn't sound difficult—just hold a compass heading and maintain a specified altitude—but it's fraught with distractions. "Okay," the instructor said, letting go of the yoke, "you've got it. Remember to keep looking for other aircraft. Scan to your left, then ahead, then right, then back again. Keep that head swiveling. Got it?"

"Got it." But I didn't. I could scan either the sky or the instrument panel, but not both simultaneously. I tended to linger on the panel—at least if I flew into someone I would do so Straight and Level.

The next entry didn't contain any abbreviations, just the word STALLS. In a properly executed stall you take a perfectly good airplane and turn it into a brick. This is accomplished by pulling the nose up, which decreases airspeed. When you lose enough airspeed, the airplane sighs, shudders, and quits flying.

The third entry noted that we delved into C&G and EMER. LDGS. Climbs and Glides weren't too intimidating, but Emergency Landings called for a constant state of vigilance that was beyond me. At any moment the instructor would reach over and pull the throttle to idle. "Your engine just froze up," he'd say. "Where are you going to land?" My answer to this question and others, such as wind direction and whom to call on the radio, was invariably, "Uh, I don't know."

By the fourth entry the Maneuvers column got a little cluttered, what with my instructor trying to document all the review work we did. I managed to find AIRWORK, which seemed to be an excuse for the instructor to liven things up. This session took place in a Taylorcraft certified for aerobatics. The instructor took the controls and told me to relax for a while. Suddenly the horizon cartwheeled and I was thrown against the seat back. It was like being strapped inside a clothes dryer. When he finished he looked over at me with a smug expression and said, "You all right?"

"Dandy."

"That was a snap roll. Want to try one?"

"No."

UNUSUAL ATTITUDES was never abbreviated. Since the entry alone takes up about a quarter of the tiny space allotted to describe the maneuvers accomplished, instructors don't do it very often, which is fine with most students. Unusual Attitudes rated right up there with Airwork. The point of the exercise wasn't so much how to get into Unusual Attitudes but how to get out of them, just in case you find yourself upside down, hanging from the seat belt and wondering why you aren't spending the weekends golfing.

One of the more cryptic entries was HOOD. It's not a maneuver at all—it's a device, a beak-like visor that you strap to your forehead. Once in place it prevents you from seeing anything but the instrument panel, which is how you learn to fly in clouds and rain. I spent my happiest hours aloft under the Hood because it eliminated the need to swivel. It's the closest I ever came to flying Straight and Level.

We had moved right along to TWR PRCDRS. The airport where I trained had no tower and thus no need for Tower Procedures, but a lot of airports have one, and the Federal Aviation Administration insists that you know how to talk to them. Tower Procedures in small trainer aircraft consisted of translating squawky bursts of static into barometer readings and landing instructions. If you can talk to dolphins, you can talk to towers.

I had struggled on through USE OF FLPS, TRFFC PTTRNS, T.O.s & LDGS, and finally, in my 13th hour, I soloed. Many pages later, I found that I took my private pilot flight test on September 9, 1967, after nearly 73 hours of flying. That's about 30 percent more time than the slowest student I knew had taken. I just couldn't get the hang of it.

The examiner and I hadn't been airborne more than 15 minutes before I got lost, mistaking a fan-shaped gravel pit for the drive-in theater on the chart. I don't know what he expected—I had flown up from Antioch for the test and wasn't familiar with the Sacramento area—but he was not pleased with my navigational abilities. Then, too, he grumbled about my short-field landing technique when I finally rolled to a stop 10 feet from the end of a 7,000-foot runway. In retrospect, I think he gave me my license just to avoid ever having to fly with me again.

I closed the logbook thoughtfully. It had reminded me of what I'd learned in all those hours of flying—that there's a place for people like me to be listed in those pages. Under PSNGR.

—James W. Andersen

TIBOR TOTH

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I knew I'd been here before, but I couldn't remember when.

There was the familiar lunch counter-size space, roomy enough that men paced back and forth, peering through the many windows at the alien world their craft confronted. There was the low ceiling; the worn, slightly battered apparatus—glowing scopes, slowly rotating compasses, gauges and dials; the soft chatter of old-fashioned black boxes, the smell of sweat and machinery, the pitch and heave of a lively deck.

Major James Nolan, a New York Air National Guard C-5 instructor pilot, suddenly brought it all into focus. "This aircraft reminds me more of being on a ship than any I've ever been aboard," he said. Nolan, a chubby but solidly built Annapolis graduate and former F-4 carrier pilot, should know. "The ladders, the pumps, the exposed pipes . . . just the way you stand on the deck and feel the machinery move way below you," he mused.

And I remembered: the freighter *Jefferson City Victory,* all 15,000 tons of her in the hands of a green 22-year-old ordinary seaman. There were the men pacing back and forth, peering through the many windows at the foggy straits of Honshu as I gripped the big helm. And around me, the glowing radarscopes, the smell of sweat and machinery, the pitch and heave of a lively deck . . .

The bridge-like expanse of the Lockheed C-5 Galaxy's cockpit, the narrow companionway and warren of small cabins aft of it, eerily heighten the impression of a ship with wings. The C-5's size is the factor that drives it home. The craft is so immense that conning it toward a landing feels much like racking a Great Lakes ore boat through the skies.

This airplane is so big it's stupefying. How it must have appeared to a world that had yet to see a 747—the C-5 was

It's ugly, it's clumsy, it's expensive, but most of all the C-5 is . . .

BIG

by Stephan Wilkinson

Photographs by Frederick Sutter/IDI

by some seven months the world's first jumbo to fly—is hard to imagine, for the airplane still looks (and is) considerably more massive than the big Boeing.

How can mere mortals fly so huge an airplane? Quite easily, it seems. Films of the maiden flight of the first C-5 show test pilot Leo Sullivan making a perfect touchdown on his first try. Yet that was the first time anyone had ever landed an airplane from a seat still four stories in the air when the main wheels hit the runway. (Sullivan had, of course, practiced beforehand on a C-5 flight simulator, but mid-'60s simulators weren't complex enough to precisely reproduce the kinesthetics of an approach and landing.)

"The whole time we were designing that thing it bothered me," admits Robert Z. Christopher, Lockheed's director of C-5 programs, "the pilot's eye sitting way up there, how he was going to be able to land it." Grinning, he adds, "Leo Sullivan got paid a pretty good sum of money to do it for the first time."

"I had a guy teach *me* to land this aircraft over the telephone," says Jim Nolan. " 'If you're on the glideslope when the thousand-foot markers disappear under the nose,' he told me, 'the rear mains are exactly 20 feet from touchdown. Slowly pull the power off, flare slightly, and you'll land safely every time.' " For most of an hour, I practiced the technique in one of the C-5 simulators at Dover Air Force Base in Delaware, and it worked just fine.

It also proved something that transport planes don't make immediately obvious: the bigger an airplane is, the easier it is to fly. Set a jumbo jet's heading, pitch, and power precisely enough to center the glideslope and localizer needles, and nothing short of wind shear is going to vary its course. "One reason we eliminated the complex crosswind gear on the airplane after it went into service is that an aircraft of this kind simply doesn't get blown around all that much, which was a kind of aviation discovery," says Lockheed marketing executive Charles Ray.

"When the C-5 first came into the Air Force inventory," says Nolan, "first-term pilots simply were not allowed in the aircraft. You had to have flown a full tour in a C-130 or a C-141 before you could even set foot in the ground school." That's changed. Major James Adamcik, a squadron-mate of Nolan's, had been an Air Force instructor flying low-level navigation training flights in tiny Cessna T-37 "Tweets" before he met his first C-5; another highly regarded New York Guard C-5 pilot, Anthony Simoncelli, took up flying the big transports fresh out of Embry-Riddle Aeronautical Academy and its Cessna and Piper trainers. And young David Morales, also a skilled C-5 pilot, is a former helicopter pilot with less fixed-wing experience than many a private pilot.

"Once you get over the *wow-gee whiz* part of it," Nolan says, "it's an easy aircraft to fly. The confusing things are the management of the systems, the many navaids, and crew management." But he adds, "I'd wager that in two to four hours, I could have any competent general aviation pilot taking off, flying, and landing that airplane with complete confidence."

Captain Dan Poquette, a balding, quiet New York Air National Guard pilot who normally flew DC-9s for Eastern before the strike, feels that taxiing the airplane is probably harder than flying it. He'd doubtless sympathize with the pilot who several years ago, while maneuvering his C-5 at an airport in Denmark, was forced by circumstances to turn onto a taxiway that quickly narrowed. Trees on the airport boundary encroached upon the lumbering giant's wingtip clearance. Had the C-5 been a 747, equipment with which to push it back to the runway—a towbar and tractor—would have been readily available. A C-5, however, needs not only a special towbar but a special tug, which had to be flown at enormous expense from the U.S. to Denmark aboard—you got it—a second C-5.

Lockheed has since demonstrated that a C-5 can be backed out of such an impasse with its own engines, using gobs of power and reverse thrust, but the Air Force doesn't entirely agree. Military Airlift Command—the agency that controls all C-5s—apparently feels the wing and engine pylon stresses are extreme enough that any aircraft commander needing to perform the maneuver must first phone MAC headquarters for permission.

"With a two-man crew," says Nolan, "you could go out and do something stupid and survive, then come back and say, 'Jeez, let's not do *that* again.' But not in *this* airplane. There's no hiding: everything you do is in a fishbowl. Anybody in the world who wants to know who you are, all they have to do is pick up a phone."

Nolan's own unit, the 105th Military Airlift Group, based at Stewart Airport in Newburgh, New York, will forever be known as "Lobster Newburgh," after the day someone spotted one of its C-5s being loaded with several crates of the crustaceans after a training flight to Brunswick Naval Air Station, on the coast of Maine. What had started as an innocent attempt to bring home a treat for the troops quickly became a *cause célèbre,* with tales of officers using an $8,000-per-hour airplane to indulge their cravings.

The C-5 is easily the largest piece of merchandise in the Air Force inventory. It is also one of the most expensive and touchiest.

It's hard to figure what a single C-5 is worth, since the original contract included not only the airplanes but everything from construction of bases to crew training to accumulation of spare parts. But the generally accepted figure hovers around $125 million per aircraft.

Depending on its age and degree of refinement, each of the huge birds requires anywhere from 22 to 60 man-hours of maintenance for every single hour it flies. "It's a *tremendously* maintenance-intensive airplane," says Lieutenant Colonel Victor Horton, the officer in charge of keeping the 105th Military Airlift Group's fleet flyable. It's a rare day when more than one of Horton's dozen C-5s is "a flier," as the crews call it. "And because of the need for parts," says Horton, "I'm forced to designate one as a cannibalization aircraft"—a rolling parts warehouse.

The C-5's value and relative rarity present another set of problems. The world will never know more than 135 of these airplanes: an original buy of 89 C-5A models, of which 85 survive, plus 50

C-5s await delivery at Lockheed's Georgia plant. The 139th—and last—was finished this spring.

C-5Bs—essentially a C-5A with redesigned wings and numerous detail improvements. "It's a finite resource, and it's going to get used up someday," Nolan says. "The more we use it now, the less there will be left if there's a war."

Wherever they're based, C-5s spend a lot of time parked in the harsh sun and rain, since the few hangars big enough to hold the craft are reserved for major maintenance activities. Their wires bake, relays corrode, seals deteriorate, leaks drip, and systems age. "You can fly this aircraft for days and days and everything works fine," says Jim Adamcik. "Then it sits on the ramp for three days, and you go out to fly it and everything's crumbled."

Air Force procedures present another complication: they require the strictest, most comprehensive preflight checks, some of which are questioned even by the crews whose safety they are intended to ensure. "During a preflight, we operate everything on the airplane—turn this, push that—and it means that's one less time you can operate that switch for real," says one pilot. "We even run emergency systems that some engineer designed to operate once or twice in the life of the aircraft. Of *course* they're going to break now and again."

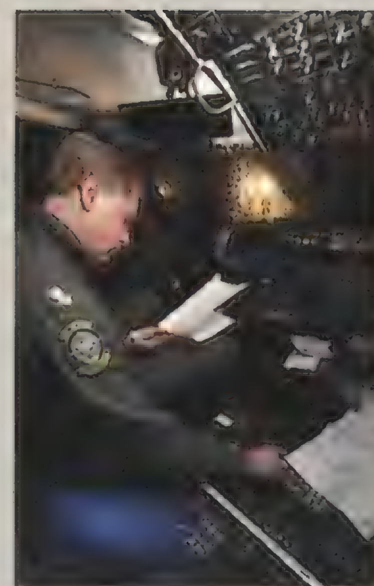
Not surprisingly, the countdown to a typical C-5 mission unfolds something like a space shuttle show, complete with holds, delays, and abrupt cancellations.

0900: "Okay, our aircraft today is balls-nine," Adamcik announces at the briefing to the 009's crew of 11. (I couldn't help wondering where Sean Connery would be today if he'd had to play Secret Agent Balls-Seven.) The mission is a two-day "Guardlift": ferry a Vermont Air National Guard F-16 squadron's tools, spares, trucks, mechanics, and extra pilots to an Air Force base in Florida for a two-week training encampment.

Adamcik, a sad-faced, soft-eyed man who nonetheless leaves no doubt who's in charge, runs through the briefing

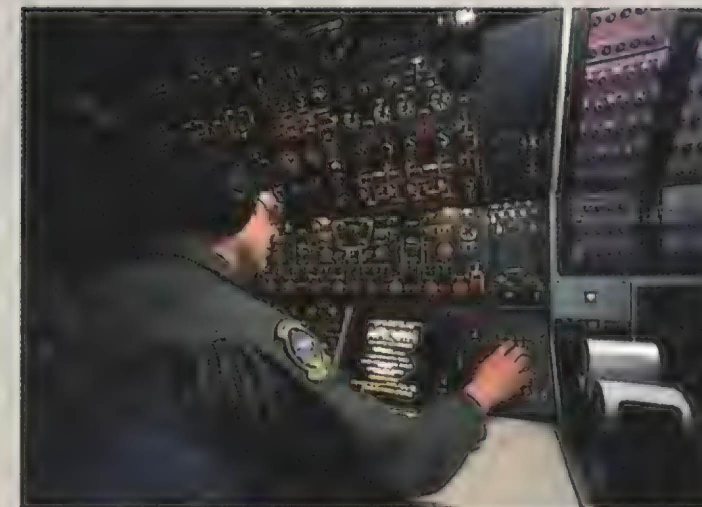
With KC-135s ready to top off their 51,000-gallon tanks, C-5s have virtually unlimited range.

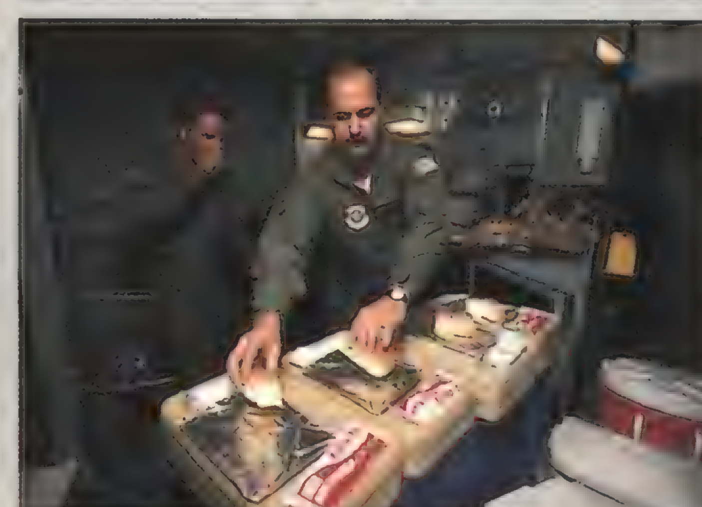
JOHN ROSSINO/FAIRCHILD

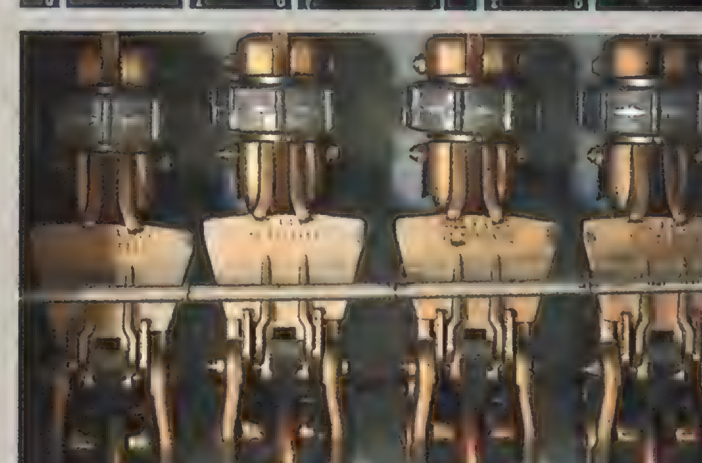


Combine systems as complex as the C-5's with Air Force procedures that require virtual perfection before a mission and it's no wonder that delays become routine. A day in the life of a C-5 involves (clockwise from bottom left):

- *hydraulics system control panel*
- *aerial refueling*
- *weather radar*
- *cockpit conferences*
- *flight management computer*
- *pilot's programming of navigation system*
- *flight engineer*
- *control yoke*
- *meal preparation*
- *fuel system control panel*
- *cargo tie-down clamps.*







boilerplate quickly. "If somebody tries to hijack us, we won't let 'em. Crew conduct: We're all big boys, so we won't go over that. Engineers, all I ask is that if you're gonna put something in the log that grounds the aircraft, do me the courtesy of telling me first."

0945: Aircraft 009 crumbles—engine problems—before we even leave ops. Our flier will now be number 169, at the moment inbound from Dover Air Force Base in Delaware. "The Ghost Ship," a flight engineer mutters: a crew chief and mechanic have been killed aboard it and a second mechanic badly hurt.

The accident rate for C-5 ground personnel is much higher than that for the flight crew, the main danger being deadly falls from the airplane's heights. For pilots, the primary hazard is the climb up the steep 30-foot ladder from the ground and through the cargo hold to the cockpit. Several have slipped and dislocated fingers when their wedding rings jammed in one of the joints of the ladder's handrail.

1105: Our new airplane has landed, only to be immediately surrounded by a clot of yellow Stewart Airport fire trucks: hot brakes, caused by several dragging wheels. Adamcik is furious as he watches the day slip away. "Who called it?" he demands. "Are they *hot*? Or just smoking?" An experienced flight engineer is reported to have made the judgment. "Okay, they're hot," Adamcik groans. The countdown stops and we go to lunch.

1330: We're finally in the cockpit and the pilots have started running their lengthy checklist. Adamcik has donned the bright orange Cleveland Browns cap he likes to wear while flying. A little-boy cowlick is poking out the back. "They were going to make me wear a New York Giants hat," says the Ohio native. "No way."

MAC crews dress comfortably—no helmets or gloves—for missions can easily last 20 hours. "This aircraft can go anywhere in the world," Adamcik says. "*Anywhere.* We took off a while ago from an 8,000-foot runway at Brunswick Naval Air Station with 100,000 pounds of cargo, hit a KC-135 [aerial refueling tanker] over Wisconsin and a KC-10 over the Aleutians, and made it to Kadena, Okinawa, in 20.5 hours. Took off with the sun just coming up and landed with it just going down."

1340: The airplane's entire nosecone grinds open, rotating ponderously up and over the cockpit to expose the cargo maw. As its chrome green interior rises outside our windows, I have the sudden gut-churning feeling that the airplane is doing an endless outside loop, as though the cockpit were slowly pitching down while its ceiling remained stationary. Far below us, the leviathan rocks and shakes as cargo is loaded.

1415: The flight deck is full of pilots, mechanics, engineers, avionics repairmen. Sweating technicians squeeze past one another in the narrow corridor through the crew's rest area. "Let's see if we can get some *more* people up here, why don't we?" says a short, tense man in camouflage pants and T-shirt. He is the airplane's crew chief, and his ire is inevitable. His job is to present the crew with a bird ready for flight, and their job is to pick its feathers apart. As far as the crew chief is concerned, pilots are people who mess up a perfectly good airplane by using it.

1515: Doors slam shut, power carts rev, and we're ready to go. No we aren't: our scanner—the second engineer, who stays on the ground linked to the cockpit by telephone until the engines are running and he pulls the nosegear downlock pin—sees hydraulic fluid pouring out of the airplane's belly. Adamcik rests his head on the huge yoke and slowly bangs his fist on the power levers. "It could be worse," observes copilot Dan Poquette, who has been listening to a local radio station on one of the airplane's navigation radios. "There's a 10-mile backup on the Long Island Expressway."

1550: A young mechanic comes into the cockpit and proudly presents a small, mauled O-ring to Adamcik. "There's your problem, sir. You're all set."

1615: "God, I love it when a plan comes together," Adamcik says wryly as we move out for our first takeoff. As we're cleared into position, the two flight engineers call out that a bleed-air valve seems stuck. Adamcik runs the engines up to 70 percent power for a minute while the engineers monitor their board, looking for the proper drop in pressure. They're doubtful. Adamcik makes a command decision. "We're goin'." As the engines spool up, the mission is already seven hours and 15 minutes old.

Is this any way to run an airline? Then again, the C-5 is no airliner. It is not designed to plod routinely, placidly, constantly between fixed, predictable, safe, highly automated terminals. But how will we fight in a six-day war with an airplane that takes half a day to be goaded into action? "An operable system in wartime and an operable system in peacetime are two different things," Nolan says. "The rules change. If I can get four engines running but some electrons in the avionics aren't flowing correctly, do you think I'm going to fly that airplane if people are shooting at me? Yup. You betcha.

"In peacetime, if the airplane isn't pretty much perfect, we don't go," he continues. "In wartime, it'll fly just fine with two of its four hydraulic systems inop, with one engine out, with various flight surfaces missing, with the entire nose radome gone. Sure, it takes hours to get a mission launched, but if there was a war on and you started the clock right now, two pilots and two engineers could get that aircraft off the ground in 30 minutes from cold, especially if we did a 'civilian preflight,' meaning we assumed that if it worked on the way in, it'll probably work on the way out."

For nearly two decades, the C-5 reigned supreme: by weight, the world's largest airplane. Today, however, the C-5 has moved back a space. It's now the *free* world's largest airplane—that chauvinistic qualifier that smacks so painfully of the sportscaster's fuss over "the battle for second place." The Soviets now have a machine, the Antonov An-124, that weighs 28 tons more. (A limited-edition giant, the six-engine An-225, weighs *248* tons more.) But the 1988 An-124 is more a C-5 clone than the quantum leap Lockheed took in 1968. "Even our instrument panel looks Space Age compared to theirs," one C-5 pilot says.

And that's saying something. The post-round-dial/pre-digital symbology of the 1960s, when vertical-readout flight instruments were briefly the rage, are found even in the newest 1988 B-mod-

C-5 Galaxy

The first C-5A flew on June 30, 1968. An improved version, the C-5B, first flew on September 10, 1985; the last produced was delivered to the Air Force on April 17, 1989. Four General Electric TF-39 turbofan engines weighing nearly four tons apiece provide 41,000 pounds of thrust each on the C-5B. Maximum payload is more than 291,000 pounds.

els; one look at the panel display in the C-5's cockpit and the most eager young commuter airline pilot would refuse to fly it. With its moving-tape readouts crawling up and down, the C-5's panel looks like something you'd find in the basement of the Empire State Building, busily keeping track of boiler pressures and water meters.

The Soviet Antonov is also a "more austere" airplane, as engineers put it. ("Which could be good," admits Nolan with an eye to his own airplane's complexity and poor reliability record.) Only the Antonov's uppermost deck, including the cockpit, is pressurized, meaning the huge cargo compartment is inaccessible in flight. C-5 crew people can enter the cargo deck anytime they want—something that has proved helpful numerous times when cargo has leaked, caught fire, or slipped its moorings.

Born in adversity and scandal, reared amid ridicule, the poor old C-5 has had a hard time of it. Incredible cost overruns and secretly sweetened deals made the original contract award the subject of considerable congressional debate. The "$7,000 coffeemaker" in the C-5's crew galley came to symbolize every military excess. The C-5's wing proved too weak to carry the airplane's intended load. The first C-5 to enter service arrived at its new base before a large press and official audience, only to lose a wheel at touchdown. Of course, the wheel rolled gaily down the runway and was the subject of considerably more TV footage than was the airplane.

"The more they tried to push the aircraft, the more it rebelled," reminisces Master Sergeant Larry Kemp, a flight engineer who has ministered to C-5s since their introduction. "We used to walk into the NCO club at Yakota or wherever and say, 'We fly C-5s,' and they'd all laugh at us because the airplane was broke all the time. We'd say, 'Yeah, but our fuel load alone is greater than your max gross'—things like that. When we first got C-5s at Travis, we'd fly 'em a little and they'd break, fly 'em a little and they'd break. But we didn't yet know how to pat them on the fanny and make them go the next leg."

The C-5 gives new meaning to the term "groundhog," for not only is it heavy enough to sometimes require vast lengths of concrete for takeoff, it also resembles a woodchuck on the run as it scurries determinedly down a runway. "We're so underpowered it's pitiful," says C-5 flight engineer Art Rice, a MAC oldtimer who says he'd rather still be flying KC-97s and Connies.

John Edwards, a Lockheed design engineer who worked on the C-5, insists, "That airframe and that engine are an optimum match. What you're really seeing is that there's no *extra* power. What power there is was put there to perform the specific missions for which the airplane was designed." Lockheed manager of aeromechanics Thomas Disney, himself an old Tactical Air Command transport pilot, huffs, "If guys think it's underpowered, they should have been flying C-124s, C-54s, C-46s like I did. It's all relative to what you're used to."

Lockheed's still proud to show a visitor promotional videotapes that display the airplane's most vaunted though least-utilized feature: its short-field, off-airport, forward-area landing capability, which at one time was to be the C-5's *raison d'être.* Tanks would growl down the C-5's ramp and clatter straight into battle, helicopter cargo would be made flight-ready in five minutes, and all those GI Joe scenes common to military contractor ads would take place in the shadow of C-5s saying "aaahhh." One Lockheed film shows a steel-helmeted young captain in a Jeep at the edge of a dark pasture talking down an approaching C-5 (actually a wooden model with winking navlights), which "lands" in the dark and disgorges Jeeps and trucks. Another uses cartoony graphics of a scene framed by jungle fronds and palm tree trunks, a little *Bridge on the River Kwai* wooden control tower on stilts in the background. A C-5 tail trundles across the bottom of the frame like a duck in a shooting gallery and moments later trundles back again, presumably departing the jungle strip.

In the real world, C-5s do no such thing. "Even if The War starts and this airplane begins to earn its cost back, would *you* put it into situations where it's at risk?" asks Nolan. "I mean, it's so valuable they guard it with loaded M-

The 28 wheels on the C-5's undercarriage help distribute the aircraft's enormous weight.

DEPARTMENT OF DEFENSE (3)

How Big Is It?

Lockheed public relations director Robert Martin rolls his eyes and crosses himself when asked how many Ping-Pong balls a C-5 could carry. "I almost got fired for that once," Martin says. "We were cranking out all sorts of interesting size comparisons—Greyhound buses, Ping-Pong balls, football fields—when the word came down that Lockheed was trying to sell A Serious Aircraft, not something to make fun of." Nonetheless . . .

- A C-5's interior cargo compartment is as big as an eight-lane bowling alley and longer than the Wright brothers' first flight.
- The unused area in the C-5's tailcone, a warren of crawlspace and cables behind the aft pressure bulkhead, is larger than the entire cargo area of a Lockheed C-130 Hercules—still the Air Force's standard tactical airlifter.
- The C-5 contains five miles of control cables and over 103 miles of electrical wiring.
- A C-5's fuel load would fill an average five-room house. The weight of the fuel alone is greater than the weight of a fully loaded Boeing 767-200 airliner.
- At 2,600 pounds, the paint on the exterior of a C-5 weighs more than a fully loaded Cessna 172.
- A C-5's 28 tires weigh over two tons, and the air that fills them weighs 181 pounds.
- Speaking of air, a C-5's air conditioners would have no trouble simultaneously cooling eight average three-bedroom houses.
- Seventeen C-5s could have flown the entire Berlin airlift—a job that required constant round trips by 308 prop-driven transports.
- Oh, yes, the Ping-Pong balls: 25,844,746 would fill a C-5's available cargo space, although their weight would be inconsequential. Make them golf balls and the airplane would be at its maximum takeoff weight with only 2,419,566 aboard.

16s and orders to shoot right here in Newburgh, New York. Gimme a break. It's going to be a hub-and-spoke operation, with the C-130s and C-141s getting shot at, not the C-5s."

For the C-5 is not only rare and valuable, it is also vulnerable—so immense and slow-flying that even a teenage Salvadoran guerrilla could hardly miss. (In fact, there has only been one fatal C-5 crash, in Vietnam, when the airplane's immense rear cargo ramp blew open; some—including the airplane's pilot—suspect the catastrophe was set off by a small shoulder-launched missile or an even more rudimentary weapon.)

Charles Ray, Lockheed's vice president of domestic marketing, explains, "In '63 or '4, the Air Force began studies to determine the feasibility of bringing into the inventory an aircraft capable of transporting *all* the equipment in the Army inventory. And taking it 'as far forward as possible'—which in walking-around language meant nobody ever intended the C-5 to get shot at. But a buzzword in those days was 'FEBA'—forward-edge [of the] battle area."

So the C-5 was burdened with a panoply of equipment it would need in order to land in the FEBA: huge, complex wing slats and flaps to allow short takeoffs and landings, a 28-wheel undercarriage that is easily the most complex part of the airplane, landing gear that can be slewed 20 degrees in either direction so the airplane can land in a strong crosswind, devices to deflate the tires in flight (for landing on soft ground) and to reinflate them for takeoff once the airplane was unloaded, an entirely self-contained loading/unloading system that would allow the airplane to operate far from loading docks or level ground, and a variety of redundant systems that are supposed to make the C-5 totally self-sufficient.

"You never know exactly what you're going to have to do in a military situation," says Ray. "Sure, if you put the C-5 into a given scenario, you end up saying, 'Yeah, it's got stuff in it we don't need.' But I can see situations where, if the scenario changes, the U.S. might someday be very glad it has all that capability in the aircraft."

Ray points out classic cases of aircraft that were designed for one job and wound up doing something else. "What was the B-17 designed for? To sink battleships. What did it end up doing? High-altitude daylight bombing. The B-52 was designed to be a nuclear bomber, and in Vietnam it ended up dropping tens of thousands of ordinary iron bombs. And now it's a cruise missile launcher. I think the C-5 will go anywhere the Air Force wants it to go, and it's capable of doing pretty much anything the Air Force wants it to do."

Yet for all the C-5's missions in life, there is one that Bob Christopher, Lockheed's director of C-5 programs, feels it won't take on. "Will they ever end up as surplus civil freighters?" he muses. "I doubt it. I think the government will use them and use them for 50 years and then they'll get scrapped."

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What Goes Up...

... must come down. And the Long-Duration Exposure Facility is soon going to—one way or another.

by Greg Freiherr

December 14, 1987, Washington, D.C.— Bill Kinard scribbles numbers on a chalkboard. Behind him NASA officials crack jokes and rib him. Kinard is part of a parade of scientists, all pitching their own projects, all wanting to get their hardware on the earliest possible flight once the shuttles, which haven't flown for a year, return to space. Kinard's proposal is different, though. He doesn't want to boost hardware into space. He wants to bring some of it back.

His target is a reusable, schoolbus-size satellite, the Long-Duration Exposure Facility. LDEF was designed to expose experiments to the environment of space in a low Earth orbit and then be brought back to Earth by shuttle so its contents could be analyzed. Carried into orbit by the shuttle *Columbia* in April 1984, LDEF was scheduled for retrieval in November 1985, but another payload bumped it from the manifest. Two months later, *Challenger* exploded, leaving the shuttle program stalled and LDEF marooned.

Over the past two years, near-record solar activity has further jeopardized the satellite's future. Tongues of superheated gases lashing out from the sun's surface have heated Earth's atmosphere, causing it to expand. The added friction has increased drag on LDEF; now the 21,400-pound satellite is losing altitude. Without a ride back on one of the shuttles, LDEF will return to Earth on its own.

Kinard, LDEF chief scientist, sketches the history of the satellite's orbit, its drop in altitude, the estimated time of impact. The joking has stopped. The room grows quiet. Just the tapping of chalk. Then nothing.

Shuttle manifest officer Jerry Fitts stares at the numbers. "Son of a bitch," he mutters.

The unsettling news that LDEF could reenact Skylab's nerve-wracking reentry persuaded NASA to reschedule retrieval from 1991 to July 1989. But the inevitable delays in the shuttle program pushed the launch of the recovery shuttle into November of this year, and then to late December—around the time of LDEF's expected reentry.

If the satellite does crash, a treasure trove of information about how different materials react to the hostile environment of space will be lost—information that could prove invaluable for the design of a space station and other spacecraft, even to eventual human life in space. Some of the experiments have been ruined by their unexpectedly long stay, but Kinard says that overall "there has been a tremendous increase in the value of the data. LDEF represents the only long-term database of environmental effects on materials, systems, and components. Everybody who has future space missions is desperately looking for that kind of information."

As LDEF's descent accelerated, it began to look as though all that information would be lost. More alarming, there was a risk, although statistically small, of injury to people and property. At a meeting in Washington last April, NASA decided that LDEF could get too low for a December mission to reach it safely. Kinard and his team took that conclusion to the Pentagon, hoping there could be some adjustments in the launch dates of either of two Department of Defense payloads scheduled for shuttles this summer. Kinard hoped to push the LDEF retrieval forward, perhaps moving it ahead of one of the military payloads. NASA higher-ups, however, had already decided the opposite.

One week later, Admiral Richard H. Truly, then NASA associate administrator for spaceflight and nominee for NASA administrator, announced a change in the flight schedules of its three shuttles. Getting the orbiters ready to fly was proving more difficult than expected. *Columbia,* which had been tapped for the LDEF retrieval mission but would first carry one of the military payloads into orbit this summer, was running into servicing problems. Galileo, a probe to be launched by *Atlantis* on a six-year trip to study Jupiter's atmosphere and moons, was in danger of missing its optimum launch time (see "On the Road to Io," December 1988/January 1989). "Our overriding objectives in this situation are to protect the Galileo window and to fly *Columbia* as early as we can," Truly announced.

The new launch lineup NASA announced involved pushing the July 1 DOD launch of *Columbia* to around the beginning of August. The space agency then held firm on the October 12 date for Galileo's launch aboard *Atlantis.* But the second DOD mission, called STS 33 and scheduled for *Discovery,* was pulled from the original lineup and inserted *after* Galileo—but before the LDEF mission. The tentative date for STS 33 is November 15; for LDEF, December 18.

"We have about a 50 percent chance of getting it," Henry Capote, one of NASA's managers of the shuttle payload schedule, said at the time. "Normally you wouldn't plan a mission with a 50 percent chance of success. But missions have to be set up in advance and once they are set up, there is not much anybody can do about it. The solar activity has gotten too bad too quickly."

In a bureaucracy there are seldom villains, just victims. One of them may be LDEF. Another is the Hubble Space Telescope, delayed from December to March at a cost to NASA of $10 million per month in upkeep. "The telescope is to be flown in the same orbiter as STS 33 and it can't fly until we fly 33," Capote says. Delaying STS 33 increases costs for the military—and diminishes the chance that LDEF will be brought

Can shuttle astronauts recover this 11-ton satellite before it crashes back to Earth? Stay tuned.

PHOTOGRAPHS COURTESY NASA

Still optimistic about the chances for retrieval, Bill Kinard is largely responsible for getting the LDEF project off the ground.

One of those responsible for getting it back to Earth, mission specialist Bonnie Dunbar aims to snag LDEF with the shuttle's robot arm.

back to Earth in one piece.

But Kinard and the LDEF team have kept the pressure on NASA. The meeting with DOD officials in mid-April had gone well: a strong alliance emerged. The LDEF experiments applicable to space station design would also apply to that of Strategic Defense Initiative satellites, prompting the defense department to urge NASA to accelerate its retrieval plans. Truly requested weekly updates on LDEF's orbit. Officially, NASA was still "assessing manifest options downstream of Galileo." But if the situation becomes desperate toward the end of the year, Kinard says, NASA and DOD might opt to move the LDEF mission into the November DOD slot.

"We feel good that a hard decision had not been made yet," Kinard says. "At least [Truly] is watching what's happening and he recognizes that if he makes a hard decision today, it might put us in jeopardy."

In late April, even the sun began to cooperate. Solar activity dropped, and for the LDEF team, some of the heat seemed to be off. Revised estimates pushed LDEF's reentry back a month—to late January, providing a wider margin of safety. "The forecast is that we're going to encounter another peak of activity," Kinard says, "but the drop we've seen has been sizeable and greatly appreciated because it buys a few days' more lifetime for LDEF."

Every day is needed. By mid-May, the deadline for moving the launch of the LDEF recovery mission to a date earlier than mid-November had passed. The shuttles and crews for the DOD and Galileo launches were already being readied: the computers had to be programmed and payload bays had to be prepped. Rescuing LDEF requires a specially trained crew and the right connectors for locking LDEF into the payload bay—as well as the proper flight path for meeting up with a spacecraft whose orbit changes day by day.

By late spring, all the LDEF project team could do was hope that the *Columbia*'s August DOD mission would come off without a hitch. Any delays in the launch or in the processing of *Columbia* after landing would push back the LDEF mission. But if NASA stayed within its revised schedule—and if the solar activity was even moderately quiet—LDEF could well be picked up in time.

The alternative could be disastrous. Calculations made by Lockheed Missile and Space Company at NASA's request show that 5,600 pounds of the satellite would make it through reentry, scatter into 430 chunks, and fan out like a shotgun blast over 10,873 square miles of earth. Conceivably, all the debris could splash harmlessly into the sea. But some would likely hit land; Hawaii and the Bahamas, southern portions of California and Texas, Mexico, most of Central and South America, Australia, much of Africa, China, India, Saudia Arabia, and Iran are all in its path.

Skylab, the last big chunk of U.S. hardware to fall out of the sky, had maneuvering thrusters that enabled ground controllers in Houston to adjust its entry so that most of the debris fell into the Indian Ocean. Yet some still hit Australia. LDEF, having neither maneuvering thrusters nor a propulsion system, cannot be controlled from the ground. The possibility of land impact is highest in Africa at 11 percent; second

highest in Central and South America at about eight percent. The overall probability of human casualty has been calculated at 0.1 percent. But "if the footprint [the area of impact] includes a densely populated area such as Mexico City, the risk of a human casualty will be 3.5 percent to 7.0 percent," according to the Lockheed report.

There will be no advance warning. Current projections have a margin of error of several weeks. They would have to be accurate to within a few minutes, even seconds, to predict impact. "And even then what could you do?" Kinard asks. "It's not a matter of having people move three blocks over. You're not going to have everybody in Mexico City come up to Houston."

If *Columbia* can reach LDEF before it's too late, the maneuvers it uses to retrieve the satellite will be like those of almost any space rendezvous. The trick will be to do the flying so that the maneuvering jets are not fired in the direction of LDEF. The exhaust could easily damage the experiments, undoing years of data in a single blast.

On his last trip into space, the commander of the retrieval mission, Captain Daniel C. Brandenstein, directed the shuttle to an orbit where the crew deployed and, 17 hours later, retrieved an X-ray telescope called SPARTAN. "LDEF is a lot bigger, but other than that it's all pretty much the same," Brandenstein says.

Astronauts will use the shuttle's robot arm to snag the satellite and haul it aboard. When satellites have been recovered previously, astronauts were able to assist the robot arm by flying out in manned maneuvering units or clamping their feet to a platform on the arm and wrestling the spacecraft in by hand. That is out of the question with LDEF. "You could certainly fly out to it and probably get it moving towards the shuttle, but getting it stopped is another thing," Brandenstein says.

Ditto for astronauts working on the retrieval from the payload bay. "It is so

It released LDEF into space, and now the robot arm will recapture it—if time doesn't run out first.

LDEF's Mission

The 57 experiments aboard the Long-Duration Exposure Facility are contained in 86 trays that cover the surface of the 12-sided, 30- by 14-foot satellite like squares on a cylindrical checkerboard. The trays were prepared by experimenters, then sent to NASA. The majority of the experiments are aimed at determining how various materials withstand extended exposure to space.

Some trays have materials that record the impact of micrometeoroids, space debris, and radiation. Micrometeoroids, fragments from exploded spacecraft, water dumped from manned space missions, even flecks of paint can endanger the lives of astronauts and the function of satellites. Scientists will study craters in the LDEF experiments to determine the number and size of particles that hit. The shape of a crater, the particles found on the crater walls, and the location of the impacts on the spacecraft should indicate whether the crater was caused by meteoroids or man-made debris. This information could tell designers of the space station where to put the crew quarters and sensitive electronics, and where to locate the heaviest shields.

The extent of damage on typical spacecraft components will also be documented. Of particular interest are studies involving solar cells, which are a convenient and effective source of power for spacecraft but especially vulnerable to damage from exposure to space. The space station may be heavily dependent on solar cells for energy.

Composites—plastics with high-strength fibers and metals inside—are planned for use in the station and other satellites because they are lighter and stronger than metals alone. But some may be very susceptible to atomic oxygen—oxygen broken down into its atomic form by solar radiation. Even the trace amounts in space can erode material. Furthermore, the extreme temperatures of space may cause composites to break apart. "Graphite has one coefficient for expansion and epoxy has another," says Bland Stein, assistant chief of the materials division at the NASA Langley Research Center in Hampton, Virginia. "They fight each other all the time, and that could cause cracks."

On board LDEF are epoxy, magnesium, and aluminum composites formed with graphite, carbon, and Kevlar fibers—the materials currently being considered for the space station. "A couple weeks before launch we were literally changing specimens in the experiment trays to get the latest materials onto LDEF," Stein says.

Also inside LDEF, earmarked for upper elementary to university students across the United States, are some 12 million tomato seeds, packaged in Dacron bags and sealed in aluminum canisters. A like number has been kept in a ground-based container to serve as controls. If LDEF is returned intact, the seeds will be packaged into kits—50 control seeds and 50 seeds from space—and distributed to schools, accompanied by at least one recommended experiment. The students will be asked to report their findings to NASA.

"We don't expect to get a lot of scientific information, especially from the lower grades, but it will be something that will give students a feeling of participation and excitement about space," says Jim Alston, a project investigator at the Park Seed Company in Greenwood, South Carolina. Dozens of types of other seeds will also be returned to Park for further research. Pioneers on Earth typically carried seeds for crops. The same can be expected of future pioneers who go to the moon and beyond. Information is needed on the effects of space on seed and how it should be packaged to survive.

massive—so big—that if two crewmen were to try to put it in, they couldn't see each other, and this turns out to be important when you're handling payloads," says Bonnie Dunbar, the mission specialist who will guide the robot arm. "You could conceivably give it a small shove and it could crush somebody."

Dunbar will direct the arm to grab either of two grapple fixtures mounted on LDEF specifically for the purpose of retrieval. In simulations at Johnson Space Center in Houston, she and the STS-32 crew are going over—and over—the different scenarios they might face. Some have to do with possible malfunctions of the arm. Others involve complications with the satellite, especially if it is approaching the shoreline of Earth's atmosphere.

"We'll just fly up nearby and decide if retrieval is a doable task," Brandenstein says. Wobbling and spinning will be the first signs that the satellite is beginning to reenter. Any motion in an otherwise stable satellite is called a rate. "If it has some rates on it but they are slow, hopefully we will be able to handle it," says Brandenstein. "If it's tumbling faster than we feel is safe, then we'll probably be out of luck."

"We have operational limits as to what the arm can withstand," Dunbar says. "If you try to grapple it when it is moving too fast, it could put an excessive torque on the arm and the arm joints could be damaged." In that case, says Kinard, "you turn it loose and get the hell away."

Dunbar feels confident that as long as the satellite has not fallen too low—they won't attempt to retrieve it if it's below 150 miles before launch—their chances of getting it aboard the shuttle are good. "My experimental work has been in the design of hardware," she adds, "so I have more than a passing interest in the materials on LDEF and what's happened to them."

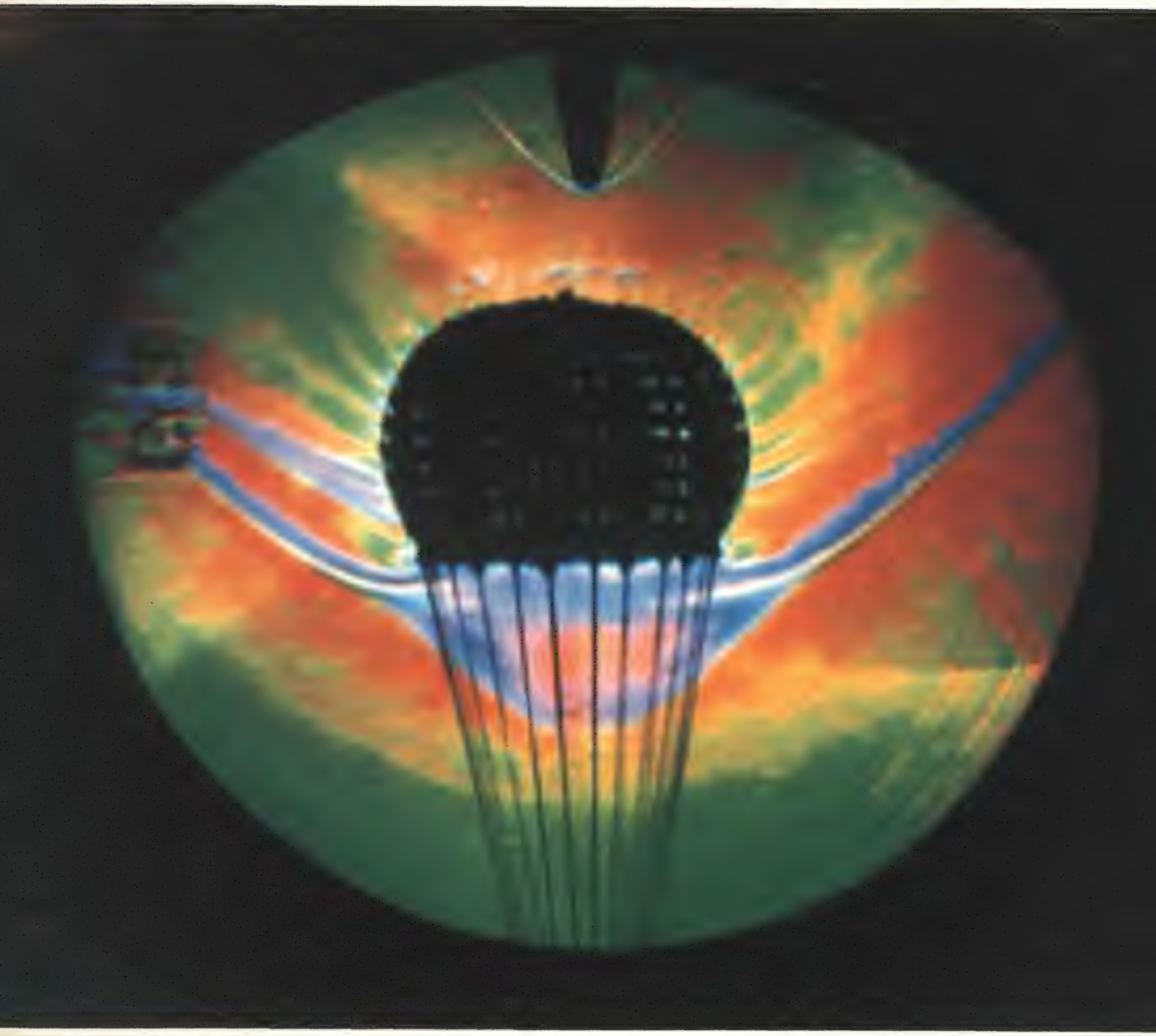
So does Kinard. His conviction comes from a career devoted almost entirely to one project. When he proposed LDEF in the 1960s, it was as the first shuttle payload. It subsequently evolved from a passive target for meteoroids into the varied collection of experiments now circling overhead (see "LDEF's Mission," above). After 20 years he's looking for a return on that investment.

"People spend years working on a spacecraft that is put on a rocket and shot into space, never to be seen again. There's something lost; it's a part of you that's gone forever," he says. "It's an entirely different feeling when you've done the work, put it on a shuttle, and it's coming back."

There is no question that LDEF will return. *How* is another matter. As Daniel Brandenstein says, "We in the crew would like to get LDEF in the shuttle, not a pickup truck."

Fast Brake

Armed with computers and wind tunnels, researchers creating today's high-performance parachutes are cutting the old methods to ribbons.



Cameras, accelerometers, and other instruments monitored an A-7's test drop over the Nevada desert.

by Jake Page

The helicopter squats amid the juniper and scrub of dusty Coyote Canyon. On the test vehicle attached underneath the helicopter, a bright patch of silver tape shines in the New Mexico sun. The tape is a target. Inside a trailer perched on a hill almost a mile away is a laser tracking system that records trajectory data and films fast-moving events. A turquoise beam of light from the argon ion laser will keep the tracking equipment locked on the reflective tape.

The color of the light seems anthropologically appropriate. Earlier in the morning the technicians found some painted shards of ancient pottery, remnants of earlier dwellers of this canyon for whom the mineral turquoise had deep significance. Now the laser that performs Space Age magic echoes the earlier kind.

A few minutes later the chopper ascends to 2,400 feet and circles above the canyon. The test is over almost before it can be appreciated. A parachute attached to the test vehicle drops from the helicopter and opens with a gunshot *pop.* When it hits the ground several technicians run to recover it from a stand of piñon pines. Others head up the hill to the laser tracker.

On the slowed-down instant replay videotape inside the trailer, engineers study the parachute as hundreds of large and small vortices of air push inside, around, behind, and through it. A computer printer pumps out page after page of data. These long rows of figures will be used to develop a computer model that will account for every important vortex that churned around the parachute.

Shock waves from a ribbon parachute in a supersonic wind tunnel reveal the complexities of deployment at 2.8 times the speed of sound.

PHOTOGRAPHS COURTESY SANDIA

Welcome to the world of high-performance parachutes. These spinnakers of descent are at best distant cousins of the generic round lightweight cloth devices packed carefully in bags to lower people or Mercury capsules from high altitudes to Mother Earth (or Father Neptune, as the case may be). The new parachutes are products of a science that spans high and low tech—from the computer to the sewing machine.

"You need a tank somewhere right away?" asks fluid dynamicist Carl Peterson. "You want to recover a scientific package from space, or a rocket booster? Drop some peanut butter and jelly sandwiches to some guys in the front lines?" High-performance parachutes are up to the task. They can produce a precisely calculated instant of titanic drag to drop some valuable piece of equipment—or a sandwich—safely to the ground from a fast and low-flying aircraft.

One of the centers of high-performance parachute design is Sandia National Laboratories in Albuquerque, New Mexico. *Sandia* is Spanish for "watermelon," and the lab shares its name with a mountain range to the northeast that glows a deep pink at sunset. Although it's one of the nation's largest research and development facilities, its modern laboratory buildings are surrounded by a sprawl of trailers, quonset huts, and pedestrian office buildings.

Sandia had its beginning in the late 1940s as an AT&T-operated lab that designed and tested all the non-nuclear parts of nuclear weapons. Parachute R&D at Sandia got started in 1953. The first project was to study the feasibility of an aircraft laying down a thermonuclear bomb slowly enough to keep the detonation from engulfing the low-flying aircraft and its crew. The Faustian business of designing parachutes for nuclear weapons still continues through an arrangement between the Department of Energy and the Air Force.

Parachutes have been around since 1617, when Fauste Verazzio made the first descent from a tower in Venice. Parachute design can be traced as far back as Leonardo da Vinci and his 15th century sketches. Since then parachutes have evolved considerably. Today most high-performance parachute designs don't even utilize the familiar panel construction—they use ribbons. Ribbon parachutes may not fill the neophyte observer with an overwhelming

Jim Strickland studies the multitude of interactions between parachute and air. The computer helps.

NICHOLAS SECOR

sense of confidence, but they work. When deploying at a speed of Mach 1 or 2, a parachute tends to create massive and instantaneous pressures and drag. Often the weight of the air trapped in the chute at the instant of deployment will exceed the weight of the object the chute is slowing down. The resulting pressure can destroy parachutes; the ribbon design allows some of the air to escape between the ribbons.

When a parachute slows a one-ton-plus vehicle from Mach 1 to a "walk" in less than a second, maintaining control of the deployment of the chute is "half the game," according to Donald D. McBride, who directed wind tunnel research at Sandia for 10 years until recently becoming supervisor of the parachute systems division.

For controlled deployment, all of Sandia's parachutes are packed into deployment bags of a type invented in 1964 by Harold E. Widdows, a Sandia engineer who retired this year with over 40 years of parachute experience. When laid open, this kind of deployment bag looks like, in McBride's words, a "four-part banana skin." First the parachute canopy is packed in, then the suspension lines, and then it is all laced up like a corset.

As is often the case with corsets, when the bag is laced up over a parachute, sometimes a lot is left hanging out. At this point packing a parachute starts to resemble medieval torture. The bag and chute are taken over to a packing press that applies some 100 pounds of pressure per square inch to the chute. Then a machine equipped with a terrifying-looking set of metal hooks pulls the laces tight. Back and forth it goes until a 50-foot chute and its attendant parts are crammed into a bag some four feet long and a foot and a half in diameter. The packed chute has the same density as a baseball bat.

To deploy the parachute, a little pilot parachute (or drogue) pops open and pulls the deployment bag out of the vehicle. The suspension lines connected to the vehicle, which were the last thing to be packed into the bag, are the first to be pulled out. They activate a row of cutters that sever some of the laces holding the parachute bag together. More lines get yanked out, which cuts more laces, and the process continues until the main chute is stretched across the desert sky—"just like on the table before it's packed," as McBride says.

BOOM, the main canopy inflates . . . and then—UMPH—something punches the top of the chute inward. It goes haywire for a second, doing an imitation of a drunken jellyfish. Lines writhe and the chute barely manages to inflate again. This undesirable phenom-

Other tests of the F-111 system have involved a B-52 and a test vehicle with the crew module's aerodynamic characteristics. The vehicle's pilot chute deploys immediately after release (left). A patented reefing system (center) opens all three main chutes (right) at the same instant.

The Corsair streaks away as the test parachute system deploys. Designed for use with a new F-111 crew module, its three canopies should open simultaneously.

enon is called "collapse." It is one of the many things that can go wrong when high-performance parachutes deploy at Mach 1, and it is the problem being studied in Coyote Canyon.

What happened is that the parachute decelerated the payload so quickly that the air behind the parachute caught up with the canopy and slammed into it. When there are only a few hundred feet—a matter of a few seconds—between inflation and the ground, this can be hard on payloads.

The Coyote Canyon tests are providing valuable data for parachute engineer Jim Strickland. He enters mathematical parameters from the tests into a computer model in an attempt to design a parachute that won't collapse on itself.

Until the 1970s the development of new parachute designs meant expensive tests. An actual flight test with a real parachute system, an F-111 fighter-bomber, and all the necessary telemetry and monitoring equipment can cost a fortune. But computers are changing that. At Sandia, one job of the 15-member team (none of whom has ever jumped out of an airplane) is to reduce the nearly chaotic intersections of air, pressure, velocity, and materials to computer models. A computer model is a lot cheaper than flight tests.

Which isn't to say that flight testing has been entirely eliminated. Computers and flight tests now complement each other. Given a set of hypothetical conditions, computer models developed at Sandia can describe an appropriate chute's size, thickness, and porosity of materials, or the ideal length for its suspension lines. But complete mathematical modeling of the physical processes related to parachute drag, canopy pressure distributions, and the wake flow field behind the parachute still comes up short—the phenomena are still too complex.

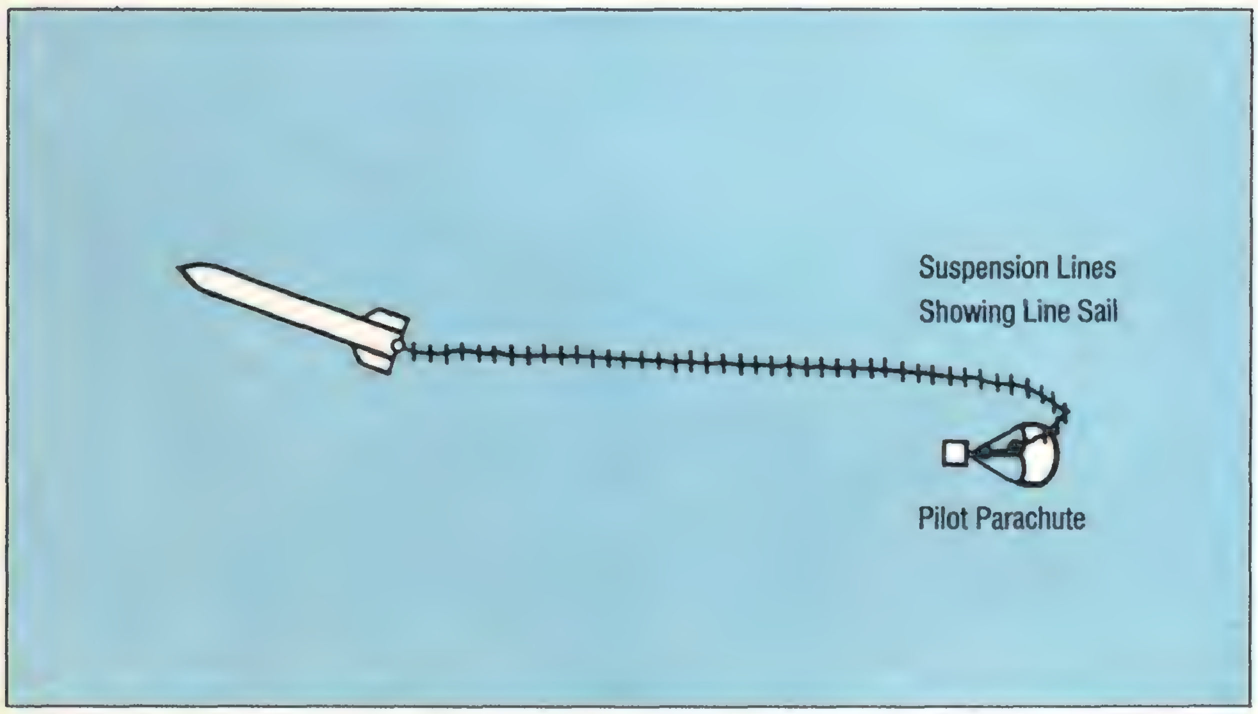
"The fluid dynamics of parachutes are among the most complex you can deal with," says Carl Peterson, who is manager of the aerodynamics department at Sandia. "It's difficult," says McBride, "because the changing shape of the parachute is dominating the very flow which is influencing its shape." There is a lag between analytical capability and the increasing demands placed on parachutes by higher-speed aircraft and lower-altitude deliveries.

A recent project at Sandia has involved computer models to design a new parachute system for the F-111. With a crew module that ejects in an emergency, the aircraft has a recovery system based on the Mercury and Gemini space vehicles. The complete pressurized cockpit section of the F-111 separates from the rest of the airplane and

Seen here in a wind tunnel, a parachute's rotating canopies offer enhanced drag and stability (top).

During line sail, suspension lines stream behind the canopy, which can damage the parachute (bottom).

Success! The A-7's test vehicle descends to the desert at less than the required 25 feet per second.



is accelerated upward by a rocket. Two parachutes are deployed to safely land the module and crew.

With new—and heavier—electronics in its cockpit, the F-111 module has gained weight, so the Air Force recently assigned Sandia the task of redesigning its parachute system. The additional weight increased the 3,300-pound module's rate of descent to approximately 35 feet per second, 10 feet per second more than the Air Force preferred. To make the landing gentler, the old parachute must be replaced by a larger one (or ones) that will lower the impact velocity by adding more drag to the parachute system.

In the building that houses the parachute lab, a stripped-down F-111 crew module sits on a cement floor amid sewing machines and devices for parachute corseting. It is not what you would think of as aerodynamically sleek. But that isn't the biggest headache for Don Johnson, technical staff member of Sandia's parachute systems division and one of the top parachute engineers in the nation. His main difficulty is that the cavity for the parachute is placed at an oblique angle and is still the same size as it was in the 1960s, when the airplane entered service. The old chute weighed 115 pounds and was 70 feet in diameter, developing a drag force of 20,000 pounds. Now Johnson has to figure out how to cram twice as much parachute area into the same awkward space.

"Parachutes are still afterthoughts in such situations," says Randy Maydew, former head of Sandia's several aerodynamics divisions. He describes a para-

Richard Brazfield and Don Johnson pack cutters into a chute. The pyrotechnic devices regulate a parachute's gradual inflation.



chute engineer's typical assignment: "Here's a hole we've left you in the back end of this thing: you design a parachute that will do the following things for it and still fit in that hole."

One of the reasons it's possible to meet such demanding specifications is that the suspension lines are now made of Kevlar, a fiber invented in 1965 by DuPont. Its strength-to-weight ratio is 10 times greater than that of steel, which means the suspension lines can be just slightly larger than the diameter of pencil lead. Johnson ranks Kevlar's impact on high-performance parachutes as equal to that of computer modeling.

To get the required parachute area, Johnson designed a cluster of three lighter-weight parachutes (employing a considerable percentage of Kevlar, of course) that would share the burden. To avoid exceeding the load-carrying capabilities of these lighter chutes, he used a time-tested parachute technique called reefing, which is similar to reefing a sail in high wind. A reefing cord is used to restrict the amount the parachute is allowed to inflate until the reefed chute slows the load to a more moderate speed. Pyrotechnic devices called cutters, which sever the reefing cord at the proper moment, are sewn into the chute and allow full inflation after this brief interval of partial inflation. However, Johnson had to invent a new "central disreef system" (which he patented) to ensure that the cluster disreefed simultaneously to keep any one parachute from being subjected to excessive loads.

NICHOLAS SECOR

Another problem with the F-111 parachute system is "line sail." The system asks for trouble because the parachute is ejected from the crew escape module at a crosswind angle. The dynamic pressures around the lines, along with the flow of air from the aircraft, cause the suspension lines to "fishhook," looping behind the parachute bag from which they are being extracted. This "cart before the horse" deployment can result in the main canopy's being damaged when it's being pulled out of the bag sideways.

It will be sometime in 1991 before work on the F-111 parachute system is completed. Johnson says he hopes to finish development of the system by the end of this year. Following that will be a qualification testing period to verify that the system can meet operational requirements. This involves another series of tests: wind tunnel, rocket sled, and air drops from a NASA B-52.

Many other computer models still need developing. "The aerodynamics of parachutes is still an infant science," McBride stresses. He doesn't want anyone—especially his management—to think that the parachute division has all these dynamics neatly pinned down in what they call governing equations. He rattles off a series of problems that await his group: trajectory and turnover, design optimization for minimal stresses and weights, non-symmetrical problems, and on and on.

"The state of the art is not nearly as advanced as we'd like to see it," says McBride. He shies away from any suggestion that the parachute design staff at Sandia has inherited the legacy of Leonardo da Vinci—except to say, "There's no telling what a fertile mind like his could do with the technology today. Maybe we could snag him to work in our group."


H-II

Japan Is Knocking on Heaven's Door

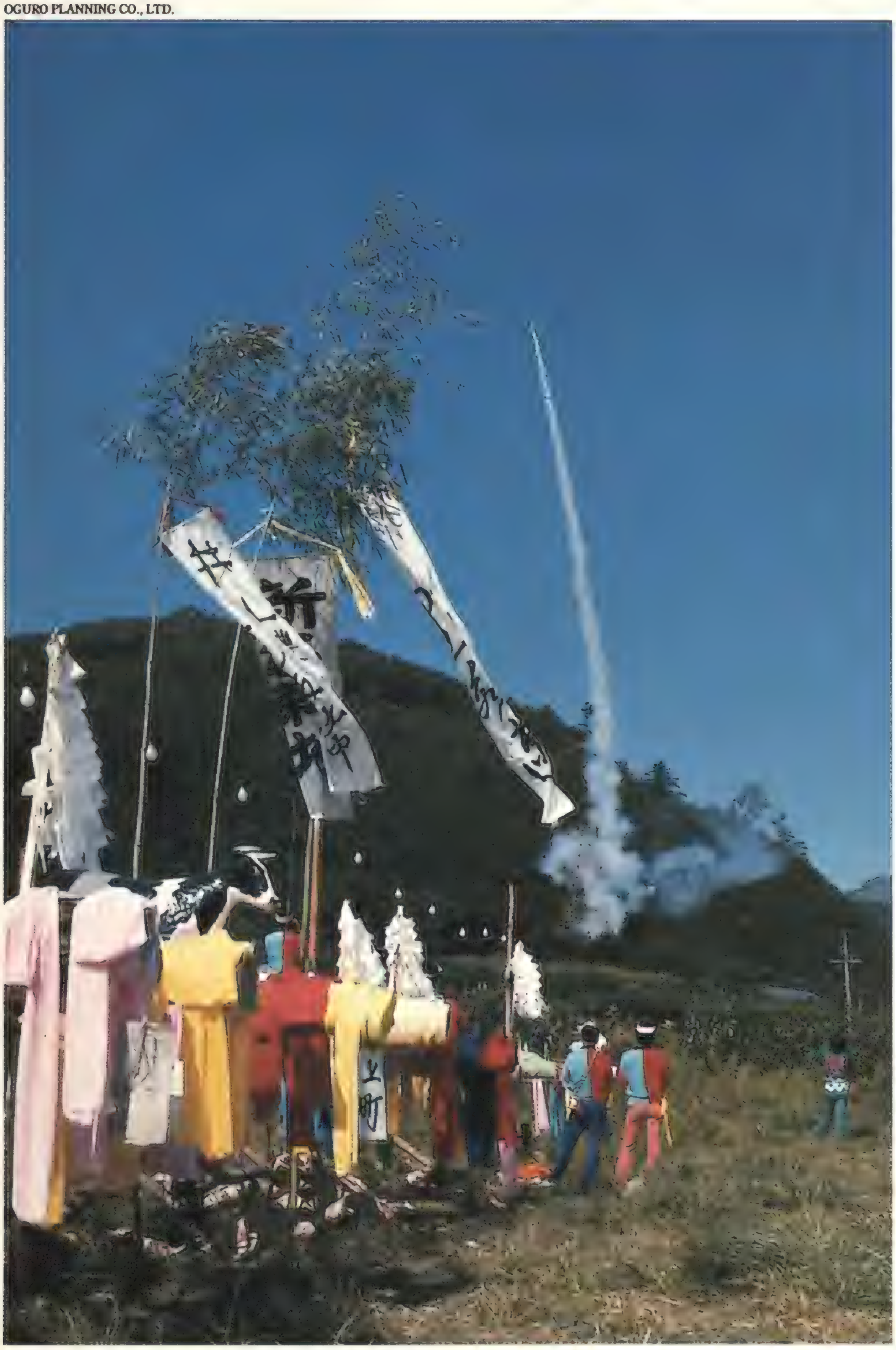
A powerhouse rocket and a shuttle named HOPE will end reliance on U.S. technology.

The world's strongest economic power is now a space-faring nation. Will the Japanese make space the final marketplace?

by William Triplett

Photographs by Ken Ueda

OGURO PLANNING CO., LTD.



Having trounced the competition in automobiles, electronics, and, most recently, microprocessors, Japan has only to announce a new interest to alarm U.S. industry. At recent international conferences on space, however, Japanese officials have been announcing more than just an interest. They have been presenting plans that could challenge Western leadership in space. Is the Japanese challenge real? Like a Zen paradox, it is and is not. Each presentation suggests but doesn't explain. Each describes an array of spacecraft and missions, and each confesses a limitation of resources. A Western listener is reminded of a well-known Zen meditation, "Where there is nothing, there is all."

Japanese culture has always been both knowable and unknowable, leading many outsiders to characterize the Land of the Rising Sun as a land of beguiling contradictions. In Japan you find a technology-obsessed people still practicing the traditions of their ancient ancestry. Shinto priests bless the rockets that come off the assembly line at Mitsubishi Heavy Industries. In Japan you also hear earnest talk about major space development, while major space spending remains more a dream than a reality.

The Space Activities Commission, which reports to the prime minister, issued a policy statement in May 1987 that identified the goal of Japanese space activities for the early 21st century: to play a central role in international efforts aimed at the development of space. Reaching that goal, the report declared, would require Japan to create a "space infrastructure" consisting of

In a nation with world-class launch technology, small rocket festivals still celebrate ancient traditions.

permanent orbiting facilities, a manned space program, and space transportation systems. Recently, Kensuke Tomita of the powerful Ministry of International Trade and Industry (MITI) described that infrastructure more specifically in an interview with *Newsweek Japan*. "We are thinking of building factories in space," he said.

The SAC report comes at the end of two decades characterized by modest projects, small rockets, and simple satellites. It seems to have signaled a change. One year after its issue, Japan's National Space Development Agency signed with NASA to become a major partner in the international space station. The Japanese will build their own station segment called the Japan Experimental Module, or JEM, which will be manned by Japan's first three astronauts, who are now in training. In addition, NASDA has described plans for a free-flying unit to conduct microgravity experiments and for an unmanned, rocket-launched shuttle (optimistically called HOPE). And several groups are doing basic research for a space plane that takes off and lands horizontally (see "How Much Hype Is in Japanese Hypersonics?" p. 60).

That's quite a shopping list for a government that allots less than one percent—barely $1 billion—of the national budget to space exploration. NASA's 1989 budget is more than ten times that amount. Japan's yearly operational costs for the space station alone have been estimated at half of NASDA's current annual budget, if funding remains close to current levels, and no substantial increases in government spending are on the horizon. Even MITI's Tomita admits, "Japan's space development budget is not suddenly going to double or triple. We can expect only a gradual increase." This is not the budgetary policy that factories in space are made of. Or is it?

"Evaluating what the Japanese are doing in space is a function of what scale one chooses to measure them," says Lawrence Aronovitch of the Massachusetts Institute of Technology, who is completing his doctorate on Japan's space program. "They're not trying to do what standard space programs might be trying to do."

So what *are* they trying to do? Direct answers are rare in a country that has always revered indirection as a social art. But looking at *how* they're doing it may answer questions about what they can achieve.

Japan's traditional strategy has been to work step by step in the wake of others who have already invested the resources to develop a technology. This strategy, which has worked so well in the manufacture of cars and electronics, has also guided the Japanese in the exploitation of space. "Our approach," says Jun Nishimura, current director of the Institute for Space and Astronautical Sciences, "has been quite efficient for us."

SYSTEMS RESEARCH INSTITUTE

In 1955 Hideo Itokawa launched Japan's space efforts with pencil rockets.

Indeed. Both ISAS and NASDA started out by transplanting technology from the West, and look at them now. ISAS, the scientific arm of the Japanese space program, grew up around a technology single-handedly imported by a young man studying medical electronics in the United States. In the early 1950s, Hideo Itokawa picked up a few books on space in the University of Chicago library. When he returned to the University of Tokyo a few years later, he assembled a team that produced the "pencil rocket," a small sounding rocket for collecting information about the atmosphere. In 1970, fifteen years after Itokawa's pencil rockets, the first Japanese satellite was launched by ISAS atop a four-stage solid-propellant rocket. It weighed 52 pounds and was designed simply for learning more about launch technology. Since then, ISAS has maintained a steady launch rate of one spacecraft a year, each mission building carefully on the lessons of the previous one. The institute has also managed to develop five launch vehicles, each with a slightly greater capability than its predecessor.

Today ISAS is internationally renowned for its scientific missions. "Their science is certainly world-class," says Stanley Shawhan, director of NASA's space physics division. "They may not be as comprehensive in their work as we are, but the parts they pick to work on they do excellently." That work has included deep-space probes to Halley's comet, as well as a series of satellites that have contributed important information to the discipline of X-ray astronomy.

NASDA, the agency responsible for earth-related applications of space technology, like remote sensing, weather charting, and telecommunications, followed a similar rise to the stars. The Japanese government started taking more notice of Itokawa's work with rockets in the summer of 1964, when the U.S. broadcast company NBC made good money from satellite transmissions of the Tokyo Olympics. The Science and Technology Agency then created the National Space Development Center to look into what practical benefits might come from space. In 1969 NSDC became NASDA, with launch operations, offices, and hardware completely separate from those of ISAS.

NASDA imported management systems from NASA and rocket technology through a licensing agreement with McDonnell Douglas to manufacture Delta launch vehicles. In 1975 the agency launched its first satellite, a 170-pound engineering testbed, aboard a liquid-

Both the H-I (above, left) and N-II launchers use first stages derived from McDonnell Douglas Deltas.

propellant rocket derived from the Delta series. For the last 14 years NASDA has launched an average of two satellites a year, each with missions narrowly focused on applications.

The copycat approach has drawn some criticism, mostly from Americans who point out that through commercial and military contracts the Japanese are getting U.S. aerospace technology for a song. "That's the reason for joining the space station," says a U.S. embassy official in Tokyo. "To learn manned space flight would cost the Japanese tons, but this way they'll learn it [from the U.S.] cheap."

The approach has clearly brought Japan to the edge of the big time. And it is likely to be the approach they continue to follow, since everything they do is a function of a single geographical fact. "From the time they're born," says an American reporter who has been living in Tokyo for most of the last decade, "the Japanese have it ingrained in them that they're a small island nation with limited resources."

When it was clear some millennia ago that the Japanese soil produced few things that would sustain a nation, the country chose to cultivate schooling, rather than depend forever on the kindness of exporters. "Historically, we have always tried to emphasize education as a resource," explains Tomonao Hayashi, a space scientist at ISAS. "Especially in the last 400 years we have made continual advances in the primary education system," he says, with an emphasis on technology studies because, aside from their obvious practical value, "they can be adopted and digested very easily."

Squeeze about half the population of the United States into Montana, strip away all but a handful of natural resources, add a rugged mountain chain that renders about a fourth of the land uninhabitable or unusable, and you would begin to see why cautious pragmatism pervades Japan—so thoroughly that it has become institutionalized.

Unlike the United States, where NASA is the sole governmental body for civilian space administration, Japan has chosen to break up such responsibility into many agencies; NASDA, ISAS, and SAC are merely the three principal ones. NASDA, with its applications mandate, may get a whopping 70 percent of the annual space budget, but ISAS enjoys a greater latitude in the kinds of projects it proposes since the government understands that space

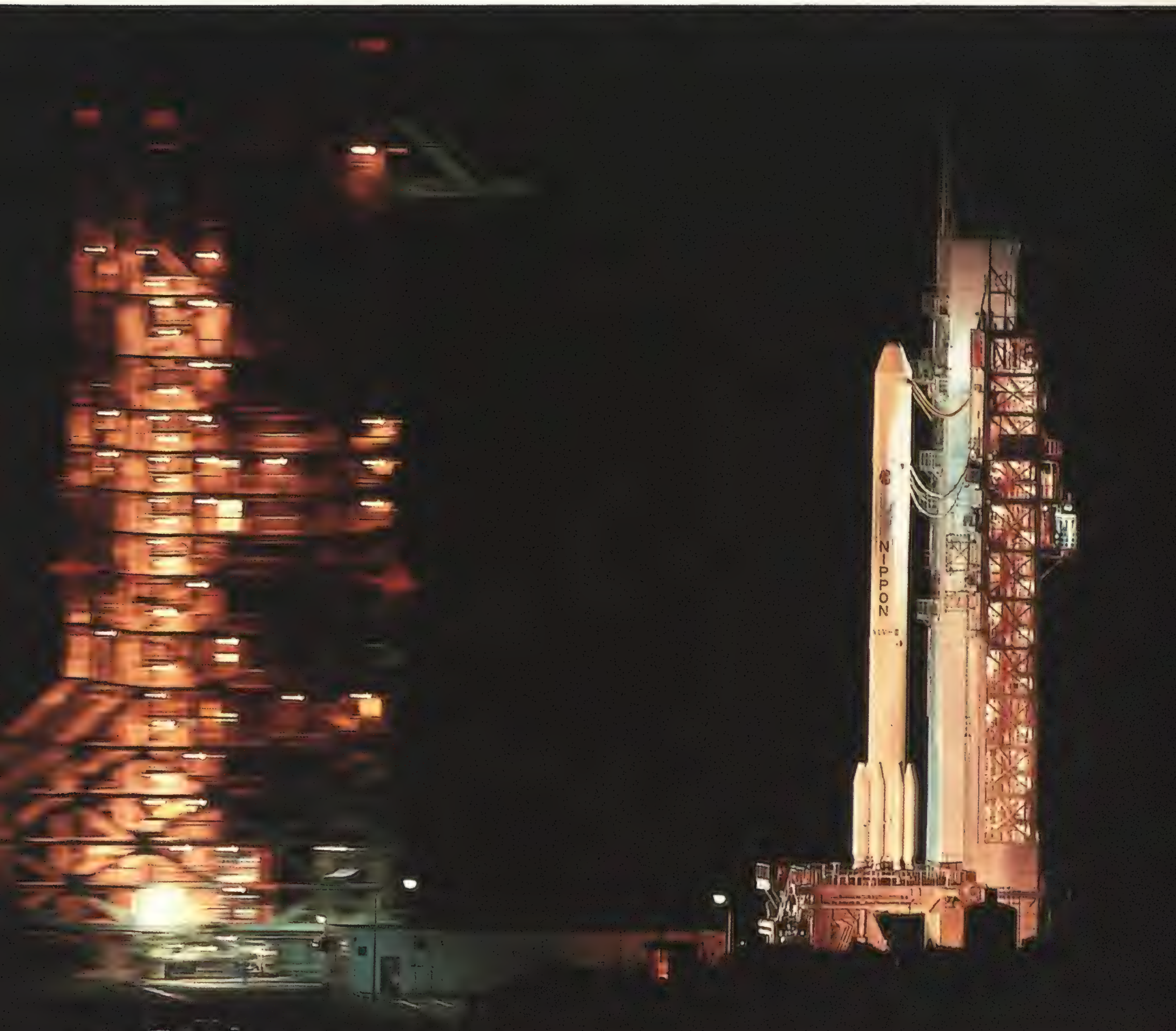
Tomonao Hayashi of ISAS oversees the launch of smaller rockets for science missions (left).

Between 1981 and 1987, eight N-IIs launched satellites for observation, communications, and broadcasting.

science may not deliver a practical benefit quickly. SAC sets the course of national space policy and coordinates NASDA and ISAS efforts.

To Westerners, this might look like multiplying the bureaucratic headache, but the Japanese are predisposed to clean lines of distinction in everything from architecture to food. There's clear method afoot here, particularly as it concerns one of the few things that does manage to grow in Japan—money.

To secure any funding, about a dozen heads—particularly the SAC's—must nod in your project's favor before you even go to the all-powerful Ministry of Finance. The result is a vastly diffused system of authority that works by consensus—the root social imperative resulting from too many people in too small a space with too few resources. Everyone must agree on how resources




NLV

will be spent. Even when not legally required, consensus rules. "It is certainly allowable for NASDA or ISAS to submit a budget to the Ministry of Finance which SAC has not approved," says Harumitsu Yoshimura, director general for research and development at the Science and Technology Agency, NASDA's parent office, "but this has never been done."

Consensus produces "a good, strong cooperating partner," according to a NASA international relations official who worked on negotiations for the space station. "That means they tend to be stable in budget outlook," he says. "When negotiating the space station, they seemed to be aware of future maintenance costs and figured those into their projections. Once they commit to a project, they stay with it."

The partnership between NASDA and NASA mirrors the sometimes thorny relationship that has developed between Japan and the United States since the war. "NASA has influenced us so much," says Hiroyuki Osawa, NASDA's silver-haired president, "that we feel like their younger brother."

Younger brother is trying to strike out on his own. When the licensing arrangement with McDonnell Douglas, which prevents Japan from offering commercial launch services, expires in 1992, NASDA will be just about ready with the H-II rocket. In the same class as the second biggest U.S. rocket, the Air Force Titan 34D, the H-II is a declaration of independence of sorts for the Japanese, since it is the first of NASDA's rockets built exclusively with Japanese technology. Two stages of oxygen-hydrogen thrust with two big solid boosters strapped to the core will generate lift close to that of the world favorite Ariane 4. The Japanese love it. The H-II brings an irrepressible smile to every NASDA official's face. Its completion heralds the departure of several U.S. aerospace firms from Japan—which should come as no surprise. Sending their foreign teachers home after learning the lesson is a tradition the Japanese have upheld ever since learning about tea from the Chinese some 1,200 years ago.

The JEM and the H-II are the only two pieces of a space infrastructure that have been funded for construction. The H-II Orbiting Plane, or HOPE, is so far just that, with research and development being conducted by NASDA but without authorization yet to build a craft. Despite official pronouncements, the next step for the space program is uncertain, and that uncertainty is key to what is, and isn't, going on.

The majority of what *has* gone on has been practical—broadcast and meteorological satellites, exploration missions for marine and mineral resources. The Japanese have a penchant for the reusable. They would never build a lunar rover, drive it once around the moon's surface, and leave it. This is why shuttles and space planes are currently driving basic research.

"The Japanese [in general] are now asking themselves, 'What can Japan do to prove that it's not just a copycat?' " says Lawrence Aronovitch. "They're approaching a crossroads with their space program, will probably hit it in the mid-1990s, and what they're doing now is trying to *plan* for it. They don't want to imitate others too much, so the question they have to figure out is 'What are we going to do?' " It is a question that cannot be answered by the complex space bureaucracy alone.

One of the foremost U.S. authorities on the Japanese, Edwin O.

Engineers prepare to attach the last solid booster to the 150-ton H-I, the biggest rocket in Japan today.

In the clean room at NASDA's Tsukuba Space Center, technicians "dust" an Earth imaging satellite.

Three Japanese organizations—the National Aerospace Laboratory, the National Space Development Agency, and the Institute of Space and Astronautical Sciences—have been doing preliminary research on reusable space planes. Although none of the three groups has been authorized yet to build a spacecraft, the Space Activities Commission, an oversight organization in the prime minister's office, has made this transportation system part of Japan's long-term space policy.

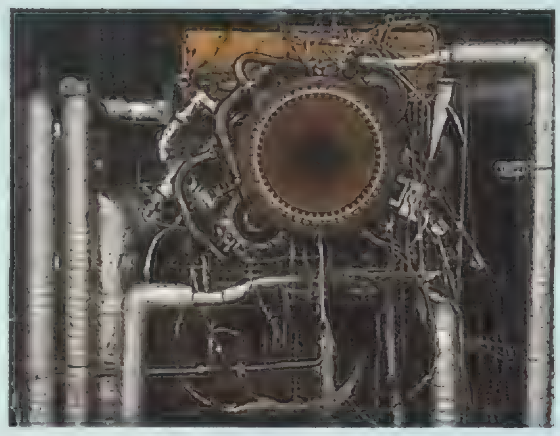
The Japanese involvement in hypersonics research is one of the chief reasons that U.S. government and industry officials have described Japan as a competitive threat to the U.S. space program. However, at least one Japanese official, Yoshifumi Inatani at ISAS, believes that the threat is being exaggerated as a strategy to protect a U.S. effort, the expensive National Aerospace Plane program, from budget cuts. (The Department of Defense cut the full $300 million NASP 1990 request to Congress, but congressional and executive agency protests were strong, and in May the funding issue went to the National Space Council.)

With $2.1 million in 1989, NAL is supporting the three leading Japanese aerospace firms—Fuji, Mitsubishi, and Kawasaki Heavy Industries—in spacecraft design studies emphasizing reusability, weight reduction, and air-breathing engines that would eliminate the need for carrying oxidizer. The goal is an experimental spacecraft with both jet and rocket engines for reaching altitudes above 60 miles at speeds up to Mach 7. The rocket engines would sustain the two-man craft in flight while permitting tests of experimental scramjets and similar engines.

At Mitsubishi Heavy Industries, engineers are pursuing the liquid air cycle engine (LACE), an air-breathing rocket. Because it is so difficult to pump gaseous air into a combustion chamber at sufficiently high pressure, LACE liquefies the air by using a device called a heat exchanger, which transfers heat from the air to a supply of supercold liquid hydrogen. U.S. companies pursued similar research on smaller engines in the 1960s but did not proceed past static tests.

Last September, Teruyuki Aoki of Mitsubishi disclosed that his colleagues are experimenting with a heat

How Much Hype Is in Japanese Hypersonics?



The LE-5 engine will test a device to liquefy air.

exchanger for an engine rated at 10 tons of thrust. It has 10,000 tubes, each one three millimeters in diameter, that will rapidly chill the air. The same group is working with a test version of the LE-5, the liquid hydrogen engine that powers the second stage of Japan's H-I launch vehicle. The heat exchanger will pump liquid air into the LE-5 in static tests this summer or fall.

"That engine was designed to use liquid oxygen," explains Tatsuo Yamanaka of NAL. With liquid air, "no one knows what the result will be."

Aoki and his colleagues have proposed using LACE-equipped liquid-fuel booster rockets instead of solid-fuel boosters on the forthcoming expendable H-II launcher, which is to enter service in 1993. The LACE boosters would rely on air-breathing technology until Mach 5.4 and an altitude of 25 miles were reached, at which point they would switch to tanked oxygen and operate as conventional rocket engines. With solid-fuel boosters the H-II can carry 11 tons to low Earth orbit, but with LACE, it could carry 30 tons.

"LACE is very simple," says Yamanaka. "It can rely on rocket technology, which Japan has been developing." But he adds, "Our experience with scramjets is very little, almost nothing. We do not have basic data. We need a major advance: to build wind tunnels and other facilities with which to conduct research, so as to obtain this data."

NASDA, by contrast, has been proceeding with what its managers regard as its own contribution to a space plane effort—HOPE, the H-II Orbiting Plane. It will rely entirely on rockets and will use no air-breathing engines. Nevertheless, Masanori Nagatomo, NASDA's director of program planning, says that "HOPE's mission will be to establish the basic technology required for the development of future space transportation systems, including the ultimate space plane."

ISAS is also working on a winged, unmanned, rocket-powered spacecraft called HIMES (highly maneuverable experimental space vehicle). With a weight of 14 tons and a length of 45 feet, HIMES is designed to carry a 1,100-pound payload of instruments to an altitude of 155 miles. ISAS researchers have carried out gliding tests on a small-scale model.

Obviously, a Japanese space plane will not fly soon. "We are thinking in terms of the 21st century, 2005 or 2010, after the space station is complete and the money is available," says Kensuke Tomita of the Ministry of International Trade and Industry. "Even then, the space plane is still just one space megaproject candidate. I think it would be best for each country to join in the development together and then share its benefits. I can't see any reason why each country would have to have its own program. The burden would be too great, even for America, to go it alone."

American observers, however, can see plenty of reasons. Wolfgang Demisch of UBS Securities, a leading Wall Street aerospace industry analyst, notes that "space planes represent cutting-edge technology, which the U.S. would be reluctant to share. If [the Japanese] put up some money and get all our advanced technology in return, that would not be a good deal."

NASDA's Nagatomo agrees: "The U.S. is confident of the lead it has in this particular field. It will not easily sell it off to one of its most dreaded rivals.

"This does not mean that Japan will have to go it alone," he continues. "International cooperation will eventually become necessary in a megaproject such as this one. But if Japan wants to be an 'equal partner' in the actual building of space planes, it will need something to show to the world so that it will not be treated like a subcontractor. That's why Japan needs to build at least its own experimental space plane."

—*T.A. Heppenheimer*

Reischauer, has written that decision makers in Japan ultimately depend on the general public. MITI's Tomita is looking in the same direction for space plane support. "I think it will be necessary to strengthen public acceptance," he says. But looking to Japanese popular opinion for a clue to their future space efforts is a frustrating exercise, about as easy as deciphering the meaning of the Santa Claus images that fill the pathologically commercial Ginza district around Christmastime in a country that's less than one percent Christian.

"I think the public is relatively aware of what's happening," says NASDA president Osawa. But the fact is, compared with American enthusiasm and support for its space race, Japanese public awareness is almost nonexistent. There are no TV commercials starring space shuttles. No school classes are interrupted for a televised launching. According to Nobuto Mori, the chief space reporter for the Kyodo News Service, the nation is space-literate only to the extent that the 1.15 million Japanese who have bought satellite receivers for their televisions know that their programs are coming from a Japanese broadcast satellite.

Some of the PR problem is due to Japan's unwritten prohibition against self-promotion on any level. Some is due to a tight budget that allows little money for even humble publicity. There is a PR effort, but it is directed at an international audience to prove that Japan is taking a more responsible role in world affairs and perhaps to pave the way for future international partnerships. The big future plans aren't touted by officials in conferences at home.

Explaining this reticence, space reporter Mori says, "If the bureaucrats spoke sincerely, they would say they are excited about the big projects. [The projects] will bring lots of prestige. But the officials can't say that. They must say, 'This will have practical merits for everyone.' Not everyone will follow for prestige or excitement. But all will follow for reasons of practicality."

On the subject of practical merits, the official tone is emphatic. Science and Technology Agency's Yoshimura says, "To be involved in space is to advance Japanese technology." As proof that the public realizes the value of advanced technology, most officials cite a recent poll by the *Yomiuri* newspapers showing widening public and even governmental support for activities in space.

Yet it is also true that the Tanegashima launch facility on the southeastern tip of Kyushu island is used only 90 days out of the year because fishermen, whose political clout rests on centuries of proven practical merits, claim the rockets scare the daily catch away. NASDA must pay the fishermen's union an annual subsidy to cover any losses that result every time a rocket goes up.

Japanese industry, another loud voice in the political decision-making process, has recognized the potential in space retailing. More than 40 Japanese companies have formed a consortium for space exploitation, and last year 66 firms posted a record $1.7 billion in domestic and international sales, up more than 17 percent from the previous year. Satellites accounted for almost 40 percent of sales, data relay and tracking stations accounted for 30 percent, rockets added 25 percent, and software earned about four percent.

Still, space accounts for only about two percent of those companies' total revenues. The big space money is expected from things like microgravity experiments, for producing pure pharmaceutical crystals and superconductor chips, among other items. The NEC Corporation will be heavily involved in the experiments. President Tadahiro Sekimoto says, "I believe the space station will be a space factory where new resources can only be produced there." The potential value of those unique resources is difficult to pin down; estimates have ranged anywhere from $2.6 to $18 billion by the year 2000.

Mitsubishi Heavy Industries sees the promise of residuals. As Toshio Masutani, general manager of MHI space systems, explains, the company hopes for a repeat performance of its profitable collaboration with Hideo Itokawa to develop a stronger steel for the early rocket skins: "This benefited us in many ways because the better steel we made was then used in Japanese cars and bridges. We hope for space facilities that will enable us to develop more things like this."

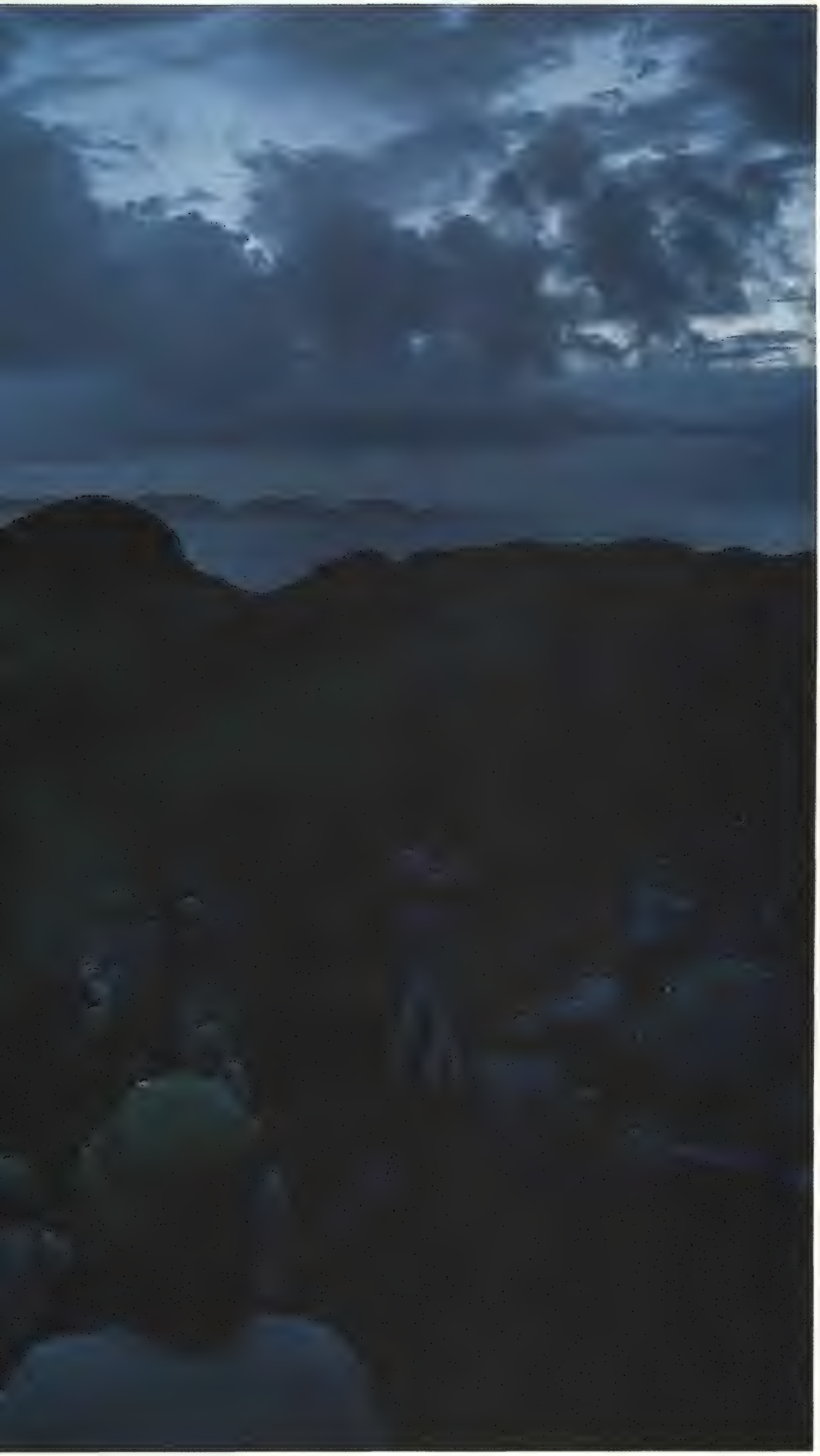
But certainties and guarantees, not

Astronauts—the newest feature of the Japanese space program—stand inside a model of JEM.

Satellite dishes, a favorite commodity, became even more popular during the Seoul Olympics (bottom).

NASDA

Though only a small crowd gathers for an H-I launch from Kyushu, the world is watching Japan's space progress.



hopes and estimates, are coin of the realm in a country that has as much use for risk as it does for American cars. And certainty about space profits is far from shared.

"That's just it," reporter Mori says. "Space development for what? Even the people involved don't know. No one really does. On paper it looks promising for business in the 21st century, but no one really believes it yet."

While most bureaucrats would respond that Japan's quest for the stars will better all humanity, Yukoh Yasunaga of MITI's space industry division agrees (albeit indirectly) with Mori. "There is no consensus yet for enlarging the space budget," he says, "because there is no consensus on the meaning of space exploration."

In Japan a lack of consensus—that gyroscope in the national psyche—first produces a kind of polite confusion, followed by a calculated disparity. "When the Japanese talk about so many different projects," says Aronovitch, "it's more than just talk. It's not that they're saying, 'We are going to do all these things.' They're feeling out the boundaries of the possible. They're throwing out ideas to see what consensus any of the projects will get."

Takaaki Yamada, an aerospace manager at MHI, recently told the *Wall Street Journal* that his country is "very good at going after dreams once they look achievable." Never have the Japanese proved that more astoundingly than in this century. But the pillars of their dreams were certainties. No one doubted the necessity of rebuilding from war rubble, and the markets for cars and electronics were established long before the Japanese entered them. Consensus was also set back in the early days of the space program, when the Japanese knew they wanted satellites and knew they would need rockets to loft them.

"There's no question they're looking for ways to make money," says an American observer in Tokyo. A NASA official elaborates: "It's another way of lessening their dependency on outside resources."

There's every reason to believe the Japanese will eventually find their way in space, once they decide what their dreams truly are—and are not.

Pan Am's Pacific

The Clippers that spanned the world's largest ocean left many lives realigned in their broad wakes.

by Henry Scammell

By almost any measure, the Pacific Ocean was the ultimate aviation conquest. But for Juan Trippe, it was second best. As president of Pan American Airways, Trippe saw the world as a series of landmasses to be connected by Pan Am routes. By the early 1930s the airline had firmly established its Caribbean and Central and South American routes, and Trippe set his sights on transatlantic travel. But his plans were thwarted by the British, who were loath to grant landing rights—and with them, dominance of the Atlantic—to a U.S. carrier—at least until they were ready to compete.

So Trippe turned to the Pacific. In the spring of 1935 Pan Am launched four surveys of a prospective commercial route from San Francisco to Manila in the Philippines via a chain of isolated islands. Laid out by Trippe and Charles Lindbergh, the routes covered Honolulu, then the islands of Midway, Wake, and Guam.

Until these flights the two-square-mile coral atoll called Midway was a cable relay station serviced solely by boat, and the three tiny islands that made up Wake were inhabited only by birds, hermit crabs, and rats. That would soon change. Shortly before the survey flights Pan Am had dispatched the depot ship *North Haven* with materials and construction crews to create air bases on the islands. Aboard were antenna masts, topsoil, flower and vegetable seeds, five tons of dynamite to create safe harbors by blasting out coral heads, and enough lumber to build villages on Wake and Guam. A later shipment included modern-day amenities for future passengers, including telephones, draperies,

Carrying 2.5 tons of fuel, a Sikorsky S-42 staggers over San Francisco at the start of Pan Am's first Pacific survey.

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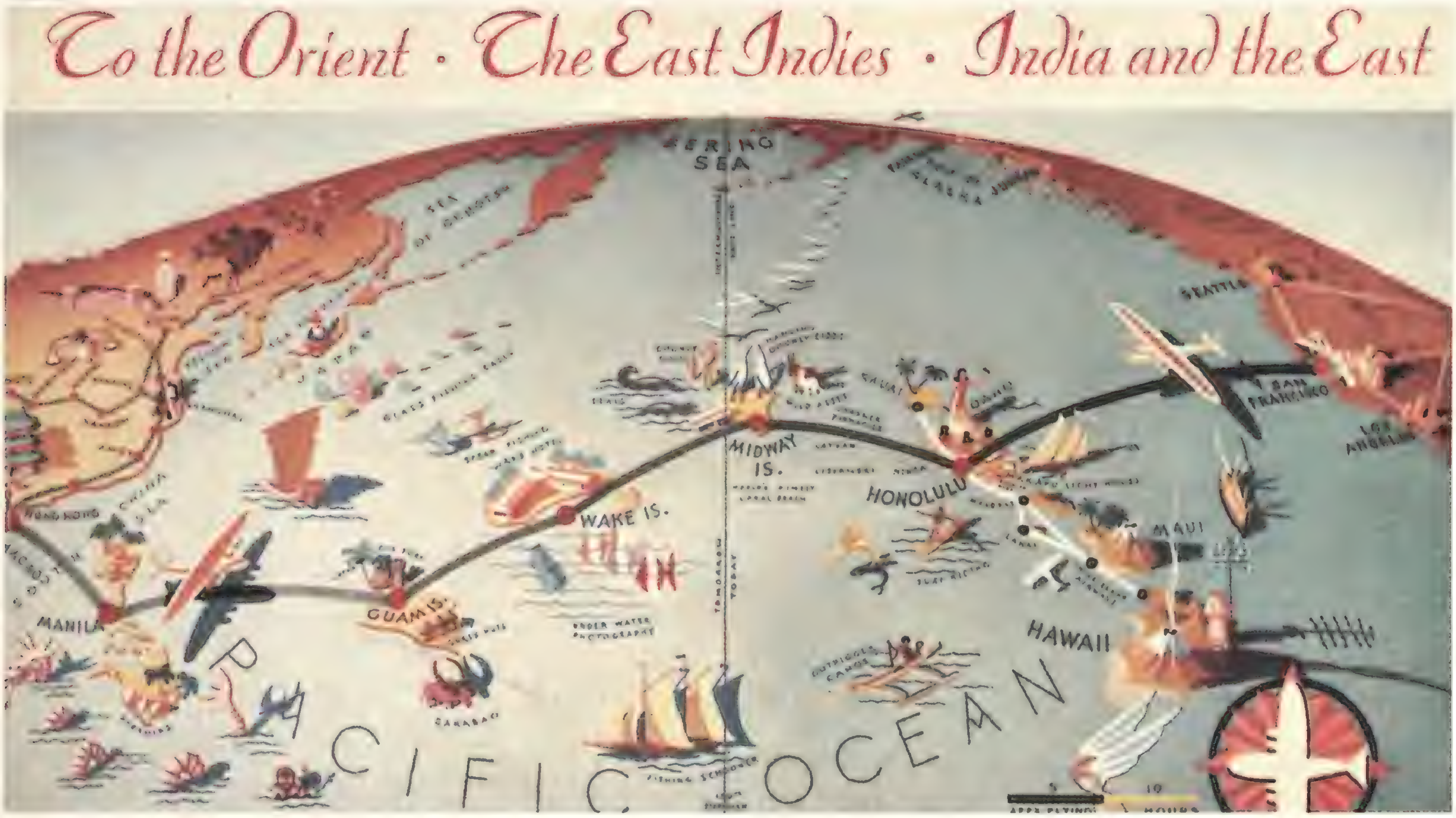

On paper, the Pacific promised romance and adventure. But the 8,200-mile route to Manila, laid out by Charles Lindbergh and Juan Trippe (below), required nearly 60 hours of flying, taxing even the ardent traveler.

Simmons beds, shower heads, playing cards, ashtrays, coat hangers, ice-making machines, aquariums, and lumber for building two hotels. On October 24, 1935, as the sole bidder, Pan Am secured the U.S. transpacific mail contract. The first flight was scheduled to depart Alameda, California, in four weeks.

For Pan Am's Pacific routes, the Glenn L. Martin Company built three M-130 flying boats, at the time the world's largest commercial aircraft. Though they could seat 32 passengers, the fuel load required for the 20-hour flight from California to Hawaii was the more crucial reason for their immense size. Indeed, on this segment only nine passengers could be accommodated.

The 26-ton Martins would herald a new age of air travel, cutting an 8,200-mile ocean crossing from weeks to days and firmly establishing Pan American as the world's dominant transoceanic airline. The first M-130, delivered to Pan Am two weeks before the mail contract came through, was christened the *China Clipper.*

John Cooke, a 25-year-old radio operator fresh out of the Navy, read about the upcoming *China Clipper* flight in the paper in Astoria, Oregon, and showed it to his wife Isyl. "Why don't I get a job with Pan Am?" he said. "We can go back to Guam."

Cooke loved Guam. The son of a Navy officer, he had spent two years there as a boy, then another two in the service before meeting Isyl. "It's beautiful," he told her. "The whole Pacific is beautiful. The moon jumps out of the ocean as big as a washtub."

"I'll believe it when I see it," she said. Cooke took that as a

yes. Three weeks before the inaugural Pacific flight, he started work as a radio operator at Pan Am's Alameda base on San Francisco Bay. On November 22, as part of an audience of 125,000, the Cookes stood on the Alameda pier long enough to see Postmaster General James Farley help stack pouches containing some 110,000 letters and to hear part of Juan Trippe's speech.

S-42 survey captain Edwin Musick got a traditional welcome after landing in Pearl Harbor on June 20, 1935.

HAWAII ARCHIVES

Cooke's task that day was to send a "Q" signal to all stations on the route. "QRV?" meant "Are you ready?" and the expected affirmative reply was the same letters without the question mark. A camera crew from Fox Movietone News watched Cooke work the telegraph key. "That was terrific," said a cameraman. "Now we'd like to get a picture of you talking to the airplane."

"I can't do that," Cooke replied. "The only way we communicate with the plane is by telegraph [key]."

"That won't do us any good," said the cameraman. "People won't understand what's happening. Pick up your desk phone and talk to the airplane."

Cooke did as he was told. "Hello, Alameda calling *China Clipper.* Over," he said to the dial tone while the camera rolled.

"Now answer him and say you got his message."

Cooke picked up the receiver again, pretended to listen for a few moments, then said, "*China Clipper,* roger. Alameda over and out."

Outside the office, oblivious to the charade being played out for the camera, Captain Edwin C. Musick taxied from the dock. The *China Clipper* grumbled interminably across the bay and finally lifted off with a flotilla of chase planes in trail. As he approached the Bay Bridge, Musick realized the burdened flying boat didn't have enough altitude to clear the uncompleted span. He lowered the nose and flew under the dangling cables. Mistaking necessity for panache, the loose formation of chase planes followed. Pan American's great Pacific adventure had officially begun.

A couple of weeks later the Cookes went to the movies to see a Laurel and Hardy comedy. The *China Clipper* flight was featured in a newsreel, and the savvy audience roared with laughter when John addressed the Clipper by phone. But the dubbed-in response brought down the house. "Roger, Alameda," said a voice as John held the dead receiver to his ear, "this is *China Clipper* landing in Manila."

Two months after the inaugural flight the Cookes followed the Clipper to Guam, where John became the chief radio operator for the Pan Am station there. By then the *China Clipper* and *Philippine Clipper* were crossing the Pacific every week.

Ben Blaz was four when the *China Clipper* first came to Guam. His parents took him down to Apra Harbor, where the flying boat was to land. Its arrival is one of Blaz's earliest and most vivid memories.

The largest and most southerly of the Marianas, the island where Blaz was born had virtually belonged to the U.S. Navy ever since Spain ceded it to the United States in 1898. The Navy employed many Guamanians—the natives were called Chamorros—and influenced everything they heard, read, or saw of life beyond their atoll.

Blaz and his parents stood patiently amid the spectators at the harbor, the boy lost in a forest of legs. Finally, a murmur passed through the crowd and Blaz's father reached down to lift him to his shoulders. He was pointing toward the water, and as Blaz squinted he saw a dot above the clouds. "Do you see?" his father asked. "Watch it carefully. Behind that little dot in the sky is the whole world."

Within a year, weekly Clipper flights were carrying passengers as well as mail. "The opening of the Pacific routes affected my future tremendously," Blaz says today. "It opened up avenues of thought and culture that we otherwise would never have known. It made it possible for books to come in, not just what the Navy fed us, and people were able to order things for the first time from catalogs. We saw American movies, and I was able to send away for a cowboy suit just like the one Hopalong Cassidy wore." In 1937 Pan Am extended its airmail flights to Hong Kong, and two years later two 41-ton Boeing B-314 Clippers joined the Martins on the Pacific routes.

Eight years ago Blaz retired as a Marine Corps general, and

A typical Clipper menu featured beef broth, lettuce hearts, Swiss steak, new potatoes, and string beans.

NASM

STAN COHEN COLLECTION

PAN AMERICAN ARCHIVES

in 1985 he was elected Guam's congressional representative. The boy by the lagoon had become part of the world behind that dot in the sky.

As the *China Clipper* first approached Manila on November 29, 1935, the waterfront park began to fill with 100,000 spectators. Among them was Dionysis Arches, who managed to work his way through the throng for a clear view of the harbor.

"Until then no one had ever seen an airplane that large or one that really connected us with the outside world," he says. "The *China Clipper* landed and the crowd clapped and cheered, on and on. I saw this was the beginning of a great adventure, and I decided then and there I wanted to be a part of it."

Arches, then 26, had taught primary school for a couple of years and then entered the mechanics' school at the U.S. Naval Station in Cavite on Manila Bay for a four-year program in aircraft, destroyer, and submarine maintenance. In short order he was hired by Pan Am as a seaplane mechanic.

"From the beginning I was proud," he says, "and even now I'm proud. The *China Clipper* changed the way I lived. Pan American gave me dignity in my work. In my society people looked at me as someone to be respected."

Not one to rest on his laurels, Arches took a correspondence course and studied far into the night for the next five years. In 1940, as Pan Am began B-314 passenger service from San Francisco to New Zealand, Arches passed the U.S. aviation mechanics exam. By the time he retired in 1971 he was working on Pan Am's Boeing 747s.

"Pan Am helped me to live better—financially, in my standing in the community, and in my family life," Arches says. "I traveled around the world to training schools in London, New York, San Francisco, and Los Angeles. I was in Manila on the day the *China Clipper* landed because it was a part of God's plan. All my prayers were answered."

In January 1941 Pan American reassigned John Cooke. The Cookes and their two sons became the first family to reside on Wake Island. They arrived by Clipper from Honolulu and Midway. "As we approached, someone pointed out a distant shape in the water," Isyl says, "and I thought they were mistaken. Wake looked like seaweed, a whole raft of kelp floating in the ocean. I said, 'This is an island?' But it turned out to be, and we lived on it."

It was a heady existence for the Cookes. Part of John's job as Wake station manager was running Pan Am's hotel. Ernest Hemingway came to try the deep-sea fishing and stayed a week. Playwright and future diplomat Clare Boothe Luce and her publishing magnate husband Henry dropped in, as did assorted movie stars and a cross-section of the world's diplomatic corps. By then the M-130s and the B-314s were providing biweekly airmail service from San Francisco to Singapore.

Thousands gathered at Alameda, California, on November 22, 1935, for the start of the China Clipper*'s first transpacific flight (left). Its arrival in Manila a week later elicited an equally exuberant waterborne welcome (right).*


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Travelers on a limited budget could get off at the first stop—the lush Pearl City base on Honolulu.

Looking back nearly 50 years later, Cooke admits that, despite the glamour, 1941 "probably wasn't the best time" for an American family to be pioneering on Wake. The U.S. military was beefing up its Pacific outposts and war seemed a certainty. That November, despite the Cookes' objections, the Navy moved Isyl and their sons to Oahu's Pearl Harbor just in case Japanese forces made it as far as Wake.

Australia was the next Pan Am target in a route that was growing like Topsy, but the Pacific Division was operating in the red with no financial relief in sight. Having conquered that ocean, Trippe had poured most of Pan Am's cash into the fledgling Atlantic division, which, alone of all the aspirants for the privilege, had started transatlantic service in the summer of 1939. Several months later war engulfed Europe, and the following year tensions began rising between the United States and Japan. Pan Am's material losses in the Pacific were about to surpass the financial.

At 6:30 in the morning on December 8, 1941, the *Philippine Clipper* took off for a routine 10-hour flight from Wake ("Where America's Day Begins") to Guam, 1,500 miles to the west. On Midway it was still December 7.

Winfield Scott Cunningham, a Navy lieutenant and the senior military man on Wake, was confused by a terse message he had just received from Naval Command at Honolulu. He walked down to the pier where John Cooke was watching the *Philippine Clipper* disappear, showed him the message, and asked what he thought of it. As in other potential hot spots around the world, Pan Am employees sometimes had better access to information than the military.

Cooke looked at the paper and read: *Oahu under attack.* "I don't know," he said. He thought for a moment, then had an inspiration. "Don't we have a gunboat named *Oahu*? And isn't it on the Yangtze?"

Cunningham nodded, relieved. "Why didn't I think of that?" he said. It was a good guess—four years earlier Japanese dive bombers had attacked the *Panay,* another U.S. gunboat on China's Yangtze River.

A moment later Cunningham received another message. "It wasn't the gunboat *Oahu,*" he shouted at Cooke. "It was the island. Condition One! Call the Clipper back!"

Cooke jumped into the Clipper launch tied to the pier and picked up the radio transceiver microphone. The Clipper was 15 minutes out, approaching the outer limits of the communications radio, and Captain John Hamilton was barely able to understand Cooke. Reluctantly, he turned the airplane back toward Wake to abort the *Philippine Clipper*'s last peacetime flight.

Pan Am meteorologist Walter Nobs was aboard the Clipper when it turned toward Wake. Nobs had watched the *China Clipper* depart Alameda six years earlier—he flew photographers and sightseers around the bay in biplanes back then—but he didn't sign up with Pan Am until 1937.

When the *Philippine Clipper* landed at Wake it was immediately refueled and unloaded with the intention of sending it out to search for the Japanese fleet. Some 200 tires that had been destined for the American Volunteer Group's P-40s in China were burned at dockside to prevent them from falling into Japanese hands, and the 100 mail sacks were turned over to the Marines, who later burned them as well. Then the Clipper was stripped of everything that could be thrown overboard and held at the dock. Nobs went to the hotel where base personnel and some of the Clipper's crew and passengers were having lunch.

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The Boeing B-314, the last word in luxury air travel, had nearly twice the Martin's passenger capacity.

Nobs had just sat down at a table near the front door with an Army Air Forces lieutenant when he heard a thud. For an instant he thought it was a construction crew dynamiting nearby, but it was quickly followed by a *thud-thud-thud.* Someone across the room yelled, "Bombs!"

The lieutenant exited so fast the screen door came off its hinges and ended up on the porch with Nobs right behind it. He crawled into a drainpipe that was part of a stack awaiting installation beside the lagoon. Once inside, however, he thought, *If they drop a bomb on this no one will ever find me,* so he crawled to the other end and waited out the first wave of the attack under a bush.

From under the shrub he watched the bombs march up the beach to his hiding place. The other thing he saw was rats. They were everywhere. They came out of the underbrush, the trees, the construction equipment, the ground. "I had rats up my sleeves, up my pants, scurrying across my face, all over me," he says. "None of them bit me. They were as scared as I was. I think they were trying to use me as a cushion for the concussions coming out of the ground."

When the attack ended and the Japanese aircraft disappeared to the south, Nobs stood up and shook himself to get rid of the rodents. Everything seemed okay. It wasn't until he got back to the airplane that he discovered two bloody holes in his shirt and a long shallow furrow across his back; a half-inch lower and the bullets would have hit his spine.

The *Philippine Clipper* had some damage as well, but it too had survived. None of the 23 bullet holes was below the waterline, and none had cut a control cable. Some 30 Pan Am

On December 7, 1941, Pan Am's Pacific service ended not with a whimper but a bang.

employees clambered aboard, and when Cooke counted heads he found he was missing only Waldo Raugust.

Waldo Raugust heard about construction work in the Pacific in 1940 from a girlfriend who worked for Pan American in San Francisco. At the time he was working on a project in Oakland, so he passed the lead on to a roommate, who was soon off to the Pacific to help build a base on Canton Island for the San Francisco-New Zealand flights. A year later a job on Midway was snapped up by another roommate. When a third job in maintenance on Wake came along Raugust's remaining roommate was about to get married, so at age 23 Raugust took the job himself.

One of the roommates who had preceded him to the Pacific was on the *Philippine Clipper* with the other Pan Am employees, waiting for Raugust to turn up after the attack. Cooke wanted to go search for him, but Clipper captain John Hamilton told him to wait with the others and keep the group together. Hamilton took the only available vehicle—a garbage truck—and sped over to the base hospital. He apparently missed Raugust by minutes.

"After the bombing stopped I saw that a number of the Guamanian boys were wounded," Raugust recalls. "I put them on a flatbed and drove them over to the hospital. The doctor there said there weren't enough beds, so next I drove down to the warehouse and brought back six cots. After the wounded workers were put to bed I went back to the base and picked up the three that had been killed outright. At the hospital we put them in rubber bags, tagged them, and put them in the reefer [refrigerator] room. Somewhere along the way I remember looking across to the lagoon and seeing the Clipper taking off." Raugust, along with military personnel and other civilian contractors, was stranded on Wake. Two weeks later Japanese troops declared them prisoners of war. Raugust was imprisoned for nearly four years in China and on the Japanese island of Honshu.

Looking back, Raugust has had no second thoughts. "I've never regretted it, not then and not now," he says. "I did a job that needed to be done." In fact, Raugust says the events that day conferred on him a singular honor. "Of all the millions of people in the world, I like to remind myself that I'm the only one of my kind, the only one of Pan Am's stateside employees to be left on Wake Island."

Raugust came home, worked for Pan Am until 1976, when he had a heart attack; he retired officially five years later.

Forty-eight hours after fleeing Wake Island and 24 hours after being reunited with his family, John Cooke stood with Hamilton in Admiral Husband Edward Kimmel's office on the top floor of the Navy Building at Pearl Harbor, reporting on the attack and the escape of the bullet-riddled *Philippine Clipper* via Midway, also in flames, to Oahu. When they finished their story, Kimmel, commander of the U.S. Pacific fleet, looked thoughtfully at Cooke, as though searching his memory. "Cooke . . . Cooke—as I recall, when we wanted your family

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off Wake a few weeks ago you put up a terrific fuss."

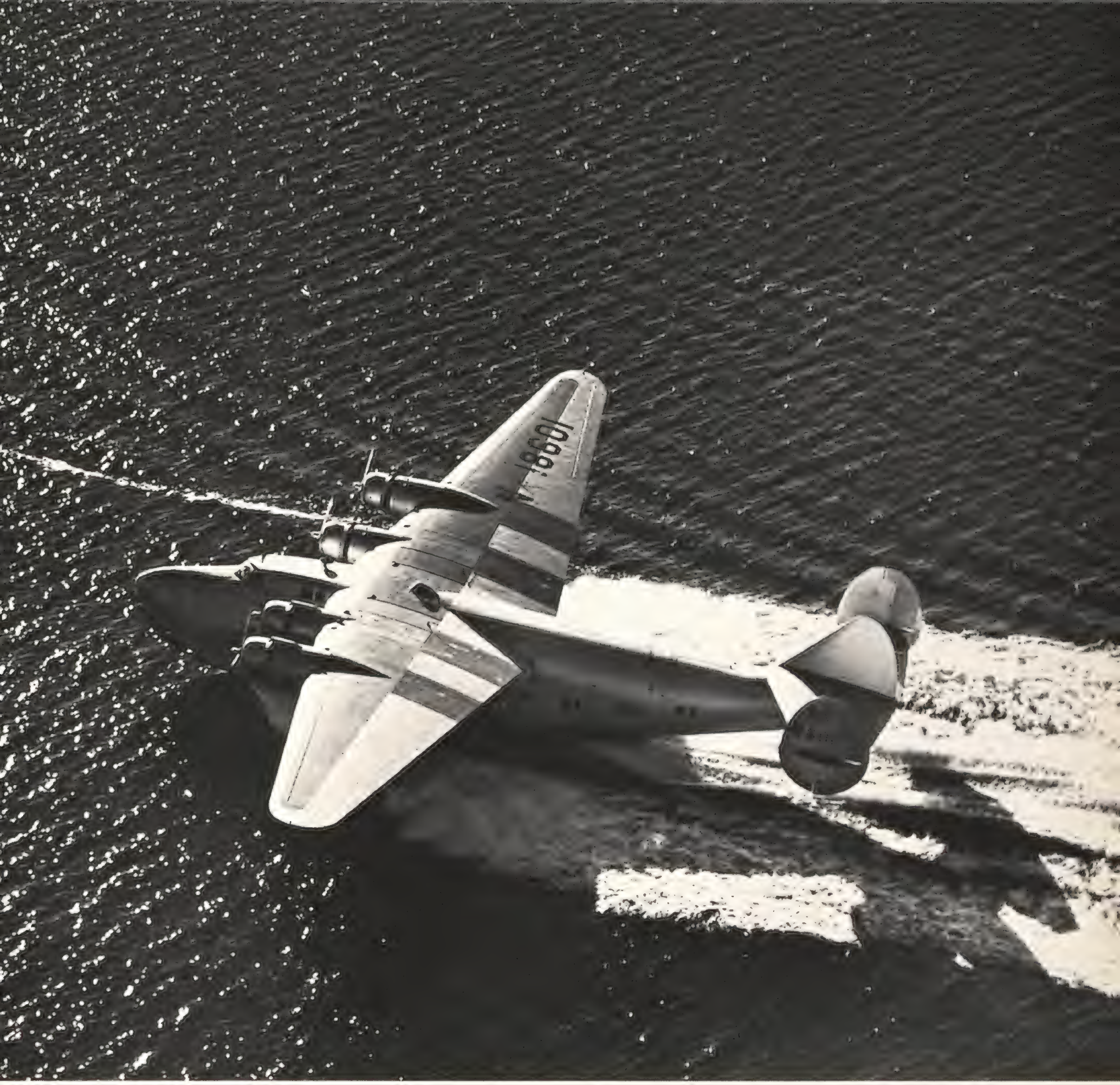
Cooke grinned sheepishly. "Yes sir, I guess I did."

"What do you think of the idea now?"

"A very, very good idea, sir."

But Kimmel wasn't willing to leave it at that. He fixed both men with a fierce stare. "That's the trouble with you civilians," he said. "You ought to know that we Navy people have far better information than you do, and that we know exactly what we're doing."

Cooke's grin faded. As a civilian, he was in the Navy Building as a courtesy—but at that moment he and Hamilton knew more than Kimmel or anyone else in the Navy about events in a part of the world that was Kimmel's responsibility to protect. Pointedly, he turned from the admiral's gaze and looked out at the devastation in Pearl Harbor. Eighteen ships of the Pacific

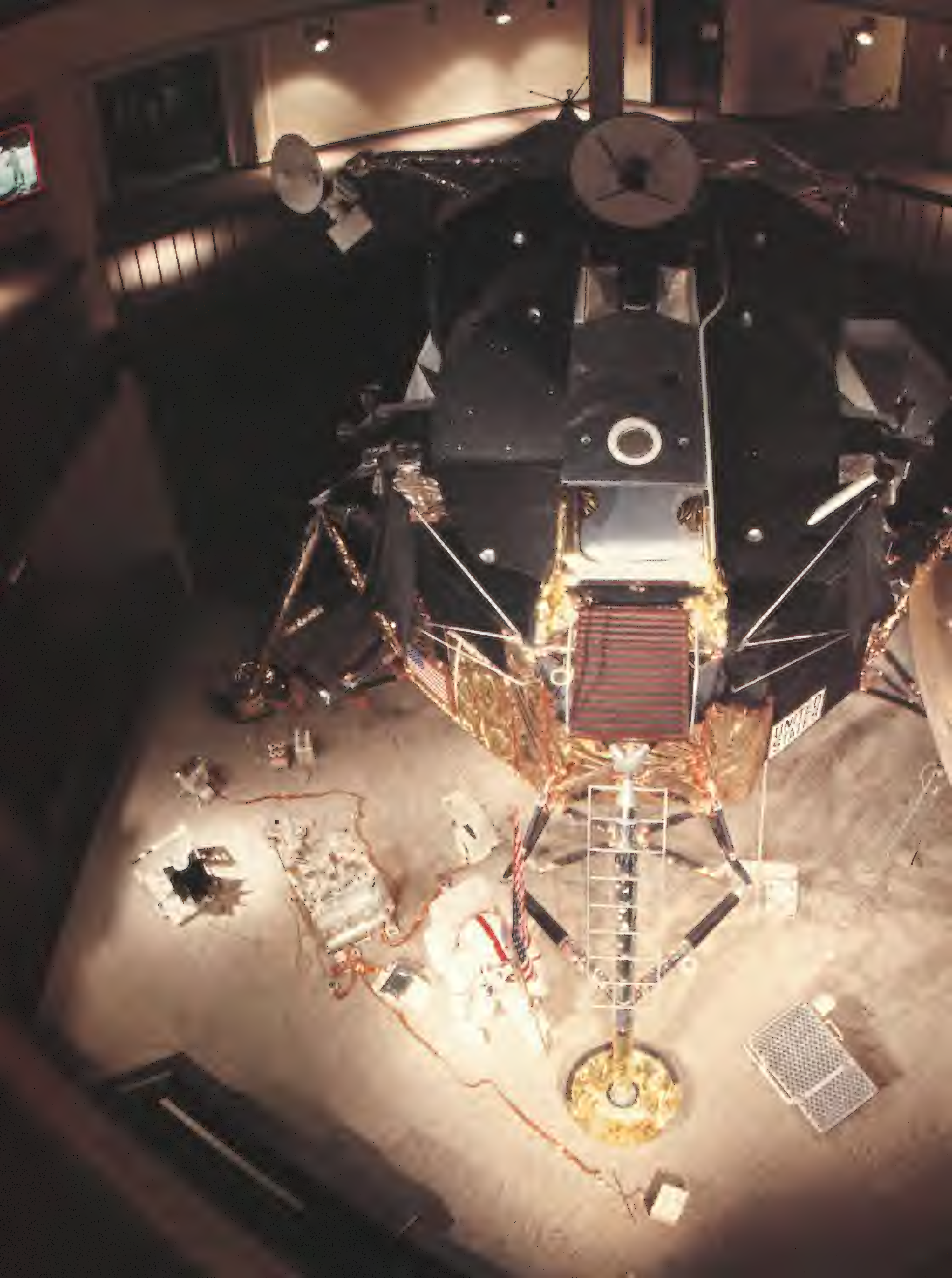


fleet had been sunk or put out of action, nearly 250 aircraft had been destroyed or damaged, and in the capsized *Arizona* alone over 1,100 sailors, unwarned and unprepared, lay entombed. Honolulu hospitals were overflowing with the burned and wounded. Below the admiral's window the wreckage still floated out with the tide and the fires still burned. Cooke turned back to Kimmel and met his glare without a word.

Later that day Cooke heard from his father, an officer under Kimmel's command. "You never should have done that," his father said. "The admiral didn't like it." But it didn't matter; a week later Kimmel was relieved of his command.

By war's end all three Martins had crashed, sunk, or disappeared at sea, and the larger Boeings were plying the Atlantic routes. In 1946 all the flying boats were replaced with faster and more cost-effective landplanes like the Douglas DC-4 and the Lockheed Constellation. Pan Am got bigger, but increased size and international competition forced it to operate more like a business and less like a goodwill ambassador and unofficial branch of the government.

In November 1985 Pan American organized a 50th anniversary recreation of the *China Clipper*'s first flight, this time in a Boeing 747. Among the guests aboard the *China Clipper II* were 100 Pacific pioneers, including John and Isyl Cooke, Waldo Raugust, Ben Blaz, Dionysis Arches, and Walter Nobs. But the festivities were bittersweet, for just months before, faced with a desperate need for capital, Pan Am had announced that it would sell all its Pacific routes to United Airlines. For those who had been part of the Pacific adventure, it was inevitable. The party had ended long ago.



Space Craft

For a small Kansas space museum, necessity is the mother of restoration.

by Devera Pine

Photographs by Chris Rainier

DENNIS BENDER

From the outside, 711 West Second Street in Hutchinson, Kansas, looks like any other machine shop in the industrial section of any other town: the building is unadorned aluminum, the parking lot unpaved and dusty. The entire lot is surrounded by a chain-link fence. The only clue that there is anything special about this address is the Redstone rocket lying in sections on the grass.

Inside, the shop is filled with the pungent odor of primers and fixatives and the noise of lathes and saws. A large sign on a door reads "Wipe your feet. No shoes allowed." In the immaculate room behind the door rests an Apollo capsule stripped to the bone.

Hutchinson is a prairie city of 50,000 where cruising Main Street is still the main pastime of teenagers on Saturday night. The town sits on the world's largest salt deposit; huge salt mines surround it. In this rural setting, the spacecraft restoration branch of the Kansas Cosmosphere and Space Center seems like something out of Oz. Here, space artifacts that have seen better days—capsules that were battered at sea, rockets that sat baking in the desert, spacesuits crumbling with age—are transformed into museum pieces.

With a huge spacesuit collection, the Cosmosphere is a leader in restoring the garments (above).

Forty percent of the museum's Apollo lunar module is original hardware—the rest, artful replica.

The Cosmosphere, originally solely a planetarium, got into the restoration business out of necessity. In 1976 the Cosmosphere's board of directors decided to expand the facility into a physical sciences museum, focusing on Earth, the atmosphere, and space. "They felt that a science education center was badly needed in this part of the country," says Max Ary, the Cosmosphere's executive director and its driving force.

Ary, who had worked at the planetarium as a college student and been called back as a consultant, had a more specific plan in mind. "I remember saying to [the board], 'How would you like to build a world-class space and science museum?'—thinking they would laugh me out of town," he recalls. "They didn't even flinch."

The museum would offer Midwesterners the chance to see space artifacts they otherwise would have to travel much farther to see. Space museums in the United States, Ary points out, are situated predominantly on the nation's perimeter, with virtually nothing in the middle.

But when it came to finding artifacts, the new museum faced a problem: the first-quality space artifacts were generally earmarked for NASA museums or the Smithsonian, and those the

Cosmosphere received were usually sorely in need of repair. In fact, much of its collection came in bits and pieces. When the Apollo program ended, for instance, the Johnson Space Center asked NASA contractors to turn over any space parts they had produced. NASA then listed all of these as excess property, meaning it didn't want them anymore. Along with representatives from other museums, Ary went to Houston in early 1976 to see what he could pick up. "We were expecting to walk into huge warehouses and see pristine lunar modules sitting there, pristine command modules that could be put on a truck and shipped back to the museum," Ary says. What they saw instead were thousands of nuts and bolts and odd parts.

But what may have been junk to others was potential exhibit material to Ary, who sent a truckload of parts back to Kansas. Over the next two years Ary returned to go through NASA's excess property list, sending more than a dozen truckloads back. "A lot of times I picked up an item and said, 'I don't know what it is, but it sure looks neat." Sometimes he could identify the part when he came across it later in a photo. But in many cases the unidentified object is still sitting in a box.

The Cosmosphere got its first opportunity to use the assorted parts to restore a Gemini capsule, a Mercury spacecraft, and a lunar module cockpit Ary "found." All were lying outside at Holloman Air Force Base, exposed to the New Mexico desert. The Gemini capsule had six inches of water in it, and the Redstone was home to a family of opossums. Other Cosmosphere displays have resulted from similar finds that have been restored: one rocket engine in the collection originally caught Ary's eye as an unusual vine-covered shape in a NASA yard in Alabama.

"Every year we hear war stories—of artifacts sitting out in some government backyard or junkyard," Ary says. "The weeds grow up, it's forgotten about, and the thing rusts away. We found a Redstone rocket on a military base; an elm tree had grown through one of the fins and we had to cut the tree down to get the rocket out. Another five years and it would have been to the point where we couldn't have recovered it. We also hear of rocket engines being purchased on the private market only for the purpose of scrapping out the metal."

Artifacts that go unrecognized are another potential problem. Recalls Ary: "We found Frank Borman's Apollo 8 checklist book in a cardboard box at one of the NASA centers under a work-

Founded primarily as a science education center, the museum aims to inspire future astronauts.

Now a tribute to the restorers' art, the Gemini-Titan II engines were among the museum's first acquisitions.

A once flight-ready command module helped train astronauts for the Apollo-Soyuz mission.

bench, about to be taken out and thrown away."

Though artifacts are becoming scarcer, Ary says competition between museums is "professional. I'll get a phone call—'Guess what I just got'—but it's done in a good spirit. Many times museums work back and forth with one another—if we can't get it, we hope one of the other museums does, simply to save it. Almost all of us have the urgent feeling that these items are quickly disappearing and we've got to do something to save them."

Derek Elliott, assistant curator of manned spaceflight for the National Air and Space Museum, describes Ary as a "scrounger," a label that Ary would probably wear with pride. "He has somehow been able to find bits and pieces," Elliott observes. "He seemed to put together a full-size lunar module from assorted parts."

Turning assorted parts into museum pieces takes a mix of skills beyond an eye for junk. The center's workmen are not retired engineers from NASA or the space industry. Rather, they are local craftsmen with experience in installing carpet and vinyl floors, fixing hydraulic systems, working with aluminum, plexiglass, steel, and fiberglass.

Nor did most of them take the job because of an interest in space. "A lot of times it wasn't anything in particular that brought them in to apply—but they get in here and they learn more about it and they decide they want to stay," says the shop's John "JL" Leroy. "It's a one-in-a-million job," he adds. "Sure, there are times when it's tedious—when you're installing gauges—but you rarely do the same thing every day. Each project is different: there are new designs, new challenges. Some of the skills you use are the same, but the finished product is never the same."

Many of the employees apply their skills off the job as well as on: one former staffer built classical guitars and harpsichords; Tom May, a member of the current team, formerly earned a living by making replicas of antique leather wagon harnesses; chief spacesuit restorer Mike Nolte spends his days off building his own house and working on a '48 Chevy and a '47 GMC truck. But, Nolte says, repairing space artifacts is special: "It's not every place where you can go to work and actually

work on the real thing." Lead craftsman Dennis Ediger agrees: "Space is something most people can't touch. Restoring something that's been on the moon—it takes you to another world."

Skills are only part of the picture. It also takes patience to carefully dissect all 32 parts of a switch in an Apollo capsule, to hand-clean each part, to struggle for perhaps days to put the switch back together—and then to repeat the procedure on the rest of the switches in the vehicle. On the Apollo capsule that the center is restoring—spacecraft 007, used for water recovery training—this is no small feat. The team will restore or fabricate 286 toggle switches and 261 circuit breakers out of some 10,000 to 15,000 switches, gauges, and other mechanisms.

Rescuing old spacecraft takes ingenuity and a willingness to work by trial and error as well. There are no manuals for repairing a battered Mercury spacecraft, no schools that train students to restore Apollo lunar modules. The Cosmosphere's experience has been learn-as-you-go.

"One of the things we learned real quick was that Apollos were not built to take apart," Ary says. "There were probably a lot of little secrets that if we could have found the right Rockwell technicians, they could have told us. But we had to learn it the hard way—we had to find which piece to take off to unveil the next set of bolts so we could take that piece off. It was like going through a maze. We'd get so far and then hit a dead end and have to put the pieces back in and try a different route." Because of the detailed work necessary in most restorations, it takes the Cosmosphere crew about two years to redo a typical spacecraft, and the cost ranges from $150,000 to $200,000.

Over the years, the craftsmen have come up with ingenious tricks for faking missing parts. If a piece of the outer shell of a space capsule is gone, for instance, they won't replace it with the original metal alloy—that would be too expensive. Instead, they'll heat and bend plexiglass and coat it with just the right shades of paint. Hutchinson's local paint store is used to the museum's requests for unusual colors: the store now carries a stock of "Apollo blue."

One of their toughest challenges was restoring a command module used to train the Apollo astronauts. NASA had loaned the simulator to Japan for an exhibition. During the return trip to the States, the ship carrying the command module almost went down in a storm. After the ship arrived, the module sat in the flooded hold for months. Finally it was removed from the hold and set on the dock, where it was exposed to rain and sun for several more months. NASA officials were ready to give the module up as a lost cause, but Apollo astronaut Eugene Cernan, who had helped arrange the Japanese exhibition, suggested sending it to Max Ary and his crew for restoration.

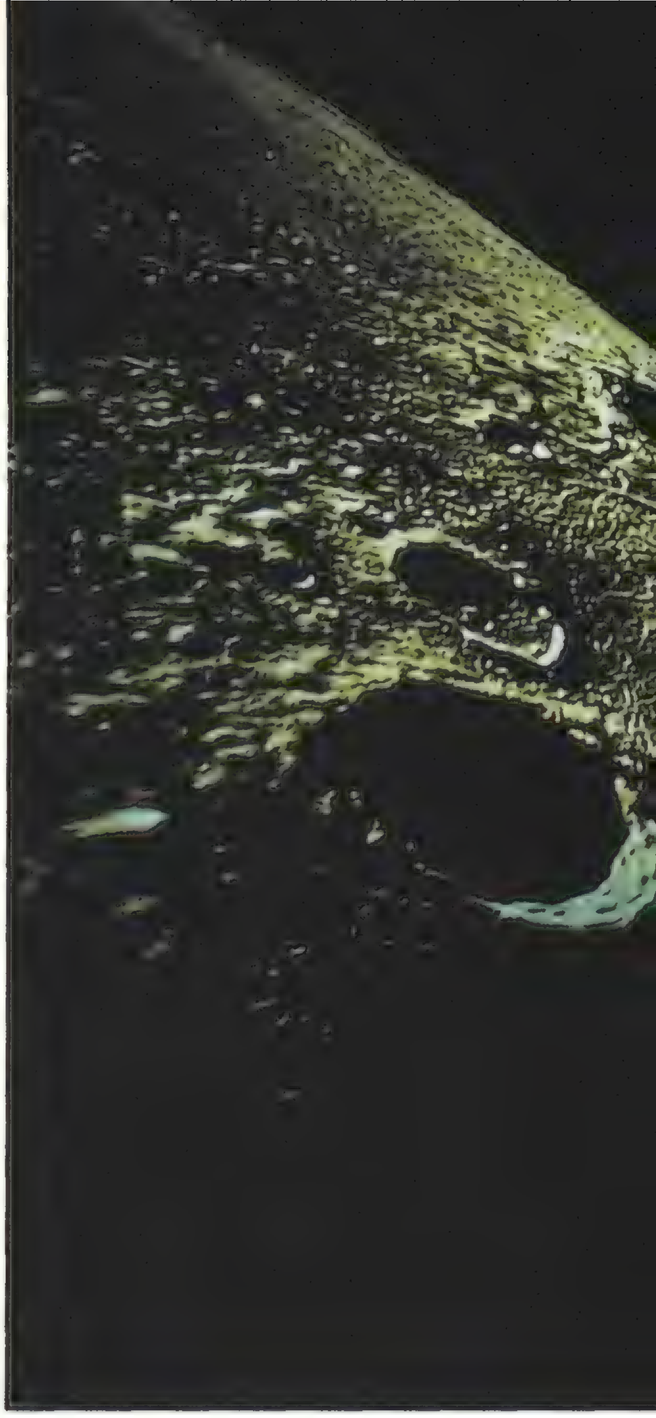
"I have to admit, I had my misgivings of whether it could be done," Ary says. Not only had all the metal rusted, but the aluminum had reacted with the saltwater and warped. And the mildew was thick enough to cut with a knife.

Fixing the capsule meant stripping it down to the frame. "We kept finding how far the water had penetrated," says curator Rick Donovan. The restoration crew salvaged the upper portion of the craft simply by scrubbing it with Spic 'n' Span and Brillo, but the lower area had to be completely replaced. Then the team pulled apart each piece of the control panel, cleaned each out by hand, and put the whole thing back together.

When the job was finished, though, the crew realized they had made one mistake: the restored craft looked too new. Former astronaut Thomas P. Stafford commented that it was in better shape than when he had trained in it.

Just how far restoration should go is always a question. But on at least one project—Mercury spacecraft number 10, a flight-ready craft that was never used—the Kansas team went to the opposite extreme, making it look as if it had survived the rigors of spaceflight and was 20 years old. "We studied almost every one of the flown Mercurys," says Ary. "We took thousands of slides of the insides and outsides . . . and found that after 20 years, there were wear points that were all the same. Paint had chipped off in certain places; certain things had yellowed." On the restored craft, the crew chipped the paint in those places and painted the gauges a faded yellow to match the paint of the Mercury *Sigma 7* spacecraft exhibited at the Alabama Space and Rocket Center in Huntsville. They even used a special dye—a cup of week-old-coffee—to make nylon laces on a replica survival kit look old.

One of the shop's most frequent jobs is the restoration of spacesuits. To date they've worked on 20, including some for NASA and the National Air and Space Museum. The crew's work, according to NASM's Elliott, is of high quality. Part of the reason for the many restorations is that the Cosmosphere has a very large collection of its own spacesuits and other astronaut gar-



Max Ary transformed "thousands of nuts and bolts and odd parts" into the Midwest's largest space museum.

Local residents, who strongly supported bringing a little bit of outer space to the rural setting of Hutchinson, reaped millions for the museum through fundraising drives and a permanently approved tax levy.

ments. When the Johnson Space Center began releasing spacesuits as excess property in 1976, Ary offered to inventory and photograph them for the Smithsonian and wound up adding dozens to the Kansas museum's collection. "Walking into this room and having 100 and some spacesuits on racks so tight that you could hardly walk down through them—I was just in awe," he says. The Cosmosphere now owns 78.

The shop's first commercial space project came when Paramount Pictures asked the Cosmosphere to build an Apollo command module from scratch for the TV miniseries "Space." Although the staff didn't intend to get into the restoration-for-profit business, projects kept coming in—so many that the museum formed KCSC Space Works, a subsidiary that handles only the building of full-scale replicas of space artifacts. Recent projects include the fabrication of space shuttle astronaut suits for museums in Fort Worth and Japan.

The work has grown to the point where the entire restoration shop is slowly moving into a bigger building a few blocks away. The museum itself is also about to launch a major fundraising drive to build an entirely new facility on a 20-acre site.

For the most part, however, the days of finding rooms filled with spacesuits or back lots dotted with historic rockets are over. But Ary says a new era in the spacecraft restoration business is about to begin. "We're starting to run into people who worked during the heyday and are retiring—cleaning out their attics, their garages. They're coming across things and trying to find a home for them." The trick, he says, is to start zeroing in on those things that people don't realize are important to museums.

As for the Cosmosphere's future, Max Ary will undoubtedly look for it in other piles of space junk. And if he gets his way, at least one will be a junk heap far, far away from Kansas. "My ultimate goal is not an American piece of equipment; it's to get my hands on Soviet equipment," he says. "I keep thinking, there's got to be this giant junkyard in the Soviet Union with all these flown Soyuz [reentry capsules] sitting out there somewhere. That would be absolutely incredible."

The Deregulation Mess

Paul Stephen Dempsey
professor of law,
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College of Law

Never before have so few airlines controlled so much air travel.

Deregulation of the nation's airline system was supposed to create a healthy competitive environment in which new airlines would spring up, fares would drop, and service would improve. But the first decade of deregulation has turned out to be the darkest period in the financial history of domestic aviation.

Deregulation freed all the major airlines to leave the more competitive markets and smaller cities so that they could consolidate their strength at hub airports. Today, all but four hubs are monopolies with incumbent airlines controlling 60 percent of gates, flights, and passengers: Chicago, Atlanta, Dallas/Fort Worth, and Denver. Even before the demise of Eastern Air Lines, the top eight airlines controlled 94 percent of the domestic passenger market. Never before has U.S. aviation been as concentrated as it is now.

Even if we disregard hub-and-spoke airports and examine pairs of origin and destination cities, 85 percent are controlled by one or two major carriers. That percentage is actually lower than it was before deregulation; but now there is no governmental mechanism to shield consumers, and monopolists can charge whatever the market will bear. The dominance by incumbent carriers of gates, terminal space, landing and takeoff slots, computer reservations systems, and the most attractive frequent flier programs makes it virtually impossible for a new entrant to challenge them. The incumbents today own all the landing slots at Chicago O'Hare, Washington National, and New York's La Guardia and Kennedy. United and American, through their computer reservation systems, account for 77 percent of passenger bookings. Even if there were new entrants willing to go against the odds, 68 percent of the nation's airports have no gates left to lease.

All of this suggests that there are economies of scale that help create significant barriers to entry in the airline industry. The theory of contestable markets, which supplied the intellectual justification for much of deregulation, has been refuted by the evidence. Even economist Alfred Kahn, chairman of the Civil Aeronautics Board during the Carter administration and the driving force behind the move to deregulate, now admits, "We were a little naive about what 'freedom of entry' meant in the airline business."

Full fares have increased 156 percent since 1978—twice the rate of growth of the Consumer Price Index. The low fares that once stimulated new traffic (mostly vacation travelers flying between large cities served by more than a single carrier) are giving way to fare increases. Many travelers still enjoy discounts, but business travelers and many others who travel on short notice cannot take advantage of them. So deregulation's benefits are unevenly distributed.

But the ticket price is not the only measure of what we pay for air transportation. Even for those who can fly on a super-saver fare, airline service today is decidedly inferior to what it was before deregulation. Flying has become a miserable experience marked by delays, overbooking, filthy airplanes, and missed connections. If we could determine the economic costs of this deterioration of air service, we would have a clearer picture of the real price we pay under deregulation, and whether consumers are really better off.

The airlines also engage in imaginative forms of bait-and-switch advertising, deliberate overbooking, market-inspired flight cancellations, and unrealistic scheduling. The airline can sell you a non-refundable ticket and

Freeing airlines from restrictive regulation was supposed to enhance competition in air travel. It certainly hasn't worked out that way.

deny you a seat despite your confirmed reservation because it booked too many passengers for the flight.

Service to small towns has gotten worse, and it costs more than it did before deregulation. More than a hundred small towns have lost *all* their service, with resulting economic devastation. Some small towns have managed to hold onto air service, but only by commuter carriers employing young and relatively inexperienced pilots flying propeller-driven airplanes. The tiny airlines that now serve small towns through circuitous connections at hub airports are not only less comfortable, they are decidedly less safe. Depending upon how it is measured, the safety record of commuter airlines is between three and 37 times worse than that of the scheduled airlines.

By many measures, there has been a sharp decline in safety since deregulation. Because profits are down, many carriers have not had sufficient resources to devote to maintenance or new equipment purchases. During the first six years of deregulation, capital devoted to maintenance *decreased* 30 percent. The number of mechanics per aircraft has declined 10 percent, even as worries about an aging airliner fleet have increased. As the profit margin has shrunk, so has the margin of safety.

Under deregulation, with every carrier adopting "hub and choke" systems that funnel their aircraft into a very narrow window of time and space, near misses have soared. In a recent two-year period, one out of every five pilots was involved in a near miss, and only 25 percent of those were reported to the Federal Aviation Administration. At the same time, airline managers insist on more productivity from pilots—more hours in the cockpit, more flights, less sleep. Fatigue is responsible for an average of two operational errors a week.

Why then, have the fatality levels not reflected the industry's miserable operating environment? First, the aircraft themselves are over-engineered. Boeing and McDonnell Douglas build a sturdy product. Even if maintenance is deferred and a critical system fails, a backup system will usually fill the void. Second, vigilance in the cockpit is better than ever. Hub-and-spoking creates intense congestion, and pilots keep a sharp eye out. And pilots are overwhelmingly concerned about the deterioration of maintenance under deregulation. They watch more carefully for mechanical problems than they ever have. Let us hope that our luck holds.

Few industries could be described as quasi-public utilities in which the public interest is held paramount and market failure is deemed intolerable. But transportation has too vast a social and economic impact to be left to the whims of a dwindling club of unrestrained monopolists. We ought to have the courage and wisdom to admit that deregulation was a mistake. We need to rectify an experiment that has gone sour before we are confronted with a monster.

This is not to say that we need to return to the tight-fisted regulatory regime of the early 1970s. Consumers were not well served by that. But consumers are ill served by a complete abdication of government oversight. At the very least, we need governmental oversight of antitrust considerations, safety, consumer protection, monopoly abuse, discriminatory and predatory pricing, and computer reservation systems. The time has come to take a fresh look and devise an enlightened response. The time has come to roll back deregulation.

The ticket price is not the only measure of what we pay for air transportation.

by Terry Gwynn-Jones

Photographs by Tony Gwynn-Jones

Every September, hundreds of pilots from all across Australia head off to this tiny desert town. What's the draw?

Birdsville Bound

TERRY GWYNN-JONES

Before the yearly festivities begin, air traffic controllers jerry-build a tower to keep watch over the hundreds of aircraft arriving at Birdsville (left). Most pilots opt to set up camp near their airplanes (right), then set off for some revelry, which often lasts till morning (above).

For 362 days of the year the skies over the Queensland settlement of Birdsville are populated almost solely by kite hawks. Their air superiority is challenged only by the occasional light aircraft and a King Air 200 bush airliner that stops off twice a week. But once each year, on the first weekend in September, hundreds of aircraft home in on the "two-men-and-a-dog town." The occasion: the world's most out-of-the-way horseraces and a colossal party at the local pub.

Last year 239 aircraft arrived at Birdsville, along with about 3,000 overlanders. According to senior constable Bob Goad, the town's only policeman, it was a modest crowd compared with those of previous years. Nonetheless, by Friday afternoon a tent city was springing up along the banks of the Diamantina River as mud-caked overlanders hit town, and the nearby airfield began to resemble a giant campground.

The annual trek to the tiny outpost is for many pilots the ultimate cross-country challenge. Birdsville is located in Australia's desert heart, 340 miles from the next town and close to a thousand miles from Brisbane,

TERRY GWYNN-JONES

CAA's Bob Williams chats with Birdsville's only policeman, Bob Goad (above). Goad's constabulary presence doesn't seem to inhibit the open indulgence in merrymaking.

the state capital. Facing hundreds of miles of featureless terrain punctuated only by a couple of low-power NDBs (non-directional beacons), pilots navigate the old-fashioned way—by compass and watch.

For Paul Greenbridge, a builder from the Queensland coast, the flight was a final rehearsal for his cross-country private pilot license test. He acted as navigator in a friend's Cessna 210. "In the last 450 miles there were no radio aids, one tiny town, and I only picked up Birdsville's miserable NDB about 10 minutes out," he reported. "I reckon I'll walk my test next week."

Not all pilots are so successful, which is one of the reasons why each year Australia's Civil Aviation Authority sets up a temporary pipe-and-canvas control tower and keeps an aircraft ready at Birdsville. CAA detachment chief Bob Williams and co-workers have shepherded several lost fliers to Birdsville over the years. As dusk approached on Friday, Williams, a former jet instructor, readied his 30-year-old Beech Bonanza. "We've already had a couple of aircraft call up unsure of their positions," he reported, "but we managed to talk them in. My worry is a Cherokee Arrow with no ADF [automatic direction finder] that won't be here before dark. I hope I don't have to go

Birdsville's track is only partially railed (left). Riders are honor-bound not to cut corners.

Lawrence Richards accepts the 1988 winning cup. The races raised $15,000 for Australia's flying doctor service and Birdsville's bush hospital.

searching for him after last light."

In addition to offering the perennial navigational challenges, the 1988 Birdsville bash also tested basic piloting skills. The main runway was closed for repairs, so operations were restricted to a 3,000-foot gravel cross-strip. Landing was a breeze for the Cessnas, the pickup trucks of the Outback ranches. But a couple of exotic, turbo-charged twins had their share of difficulty. Their pilots landed long and fast amid dust and squealing brakes before stopping perilously close to the cemetery that separates the red-dust airfield from the Simpson Desert.

By Friday evening, most of the celebrants had arrived. After settling in, they gravitated toward the pub, an old stone building with tin roof, verandahs, and hitching rails. Sinking his third beer within minutes of reaching town, Pete, an electrician from Brisbane, responded to a question about the appeal of the annual bash. "Races, mate? Naw, never go near 'em. We come here every year for a good party." The road around the pub was soon littered with yellow beer cans.

Nearby, a scattering of stalls did a brisk trade in bush hats, stock whips, hot dogs, and hamburgers. The biggest crowd was around Pierre Sinel's display. Once a fashion designer

T-shirt trafficker Pierre Sinel peddles his wares out of a stall he calls "Smutty Printz." Sinel travels all across Australia custom-designing T-shirts for special events.

In the Outback, you learn to make do. With few cigarette machines handy, many Outbackers roll their own (right). Serving as a "we come to you" gym, a boxing troupe offers aboriginal sparring partners with names like Big Red, TNT, and Maori Gentleman Jim.

for pop stars, Sinel now tours Australia selling event-designed T-shirts. His Birdsville line included the logos "I survived the 1988 Birdsville Races" (for drinkers) and "I survived my Birdsville Landing" (for pilots). Part of the proceeds was set aside as a contribution to Australia's Royal Flying Doctor service. "We've already made $300 on shirts and sold a hundred dollars' worth of beer coolers," reported flying nurse Susan Markwell, on hand to man a fundraising booth.

Meanwhile, Bob Williams' fears about the errant Arrow were borne out. The pilot, past his estimated time of arrival, had radioed that he could not find Birdsville. Williams took off and headed south; he had a gut feeling that the lost Arrow was circling there. Ahead, the last rays of twilight illuminated a patch of high cloud. Williams instructed the worried pilot to head for the cloud, then turn due north and switch on his landing light. Forty miles out, Williams sighted "a new star." "I joined up in a loose formation and brought him back," Williams later told his co-workers. "I think he's already learnt a lesson so I just gave him a verbal blast this time."

The following afternoon, five miles out of

town, the Diamantina Amateur Race Club hosted the Birdsville Races. The track is as barren as the surrounding country—there's not a blade of grass, and the only rails are in front of the crowd by the finishing post. Many of the riders and their mounts come from Outback cattle ranches, although the $26,000 prize money also attracts professional jockeys and racehorses. Placing his $50 bet on a 20-to-1 local hope, one rancher in a sweat-stained Tom Mix hat complained, "It was more fun before all the planes began bringing the city folk. In those days you knew everyone and we didn't take the races too seriously. You know, the track was so dusty then that in a close race the judge had to guess who came second and third. Things are getting too organized now."

After the races, the pilots settled down on the airfield for an early night. Self-discipline, the knowledge that tomorrow's flight would be another all-day marathon—and possibly the CAA presence—encouraged compliance with the "eight hours between bottle and throttle" rule. Besides, most planned to attend a briefing before dawn to get the weather report and submit flight plans.

At the CAA campsite the controllers

During the annual bash, Birdsville caters to a big influx of city dwellers (above); the rest of the year visitors are more often cowboys driving cattle across the central Australian desert. Outside the pub, two celebrants happily posed for a photographer, though they were loath to give their names. Many choose Outback life for its relative anonymity.

The CAA keeps a close eye on the pilots' cookouts: at past races, careless crews would light fires under an aircraft's wings.

It may be Birdsville but it's no bird sanctuary: once a year, airplanes rule.

reviewed the weekend. "Well, the worst's over," said Bob Butler. "All we've got to do now is get them off safely in the morning." With only one runway and using one-minute intervals, it would be a breeze compared with the arrival. Recalling the propeller-driven dust storms of previous years, Butler cautioned, "At briefing tomorrow, tell pilots to push their aircraft clear of the parking lines and turn 'em 90 degrees before calling for start clearance. Otherwise they'll blind their neighbors with dust."

All in all, Birdsville 1988 was a success: one aircraft lost (and found), another with dropping oil pressure safely down, half a dozen not-too-near collisions. The only casualty had been a kite hawk.

At dawn the next morning, the town woke to the roar of aircraft heading home. There was the annual traffic jam in front of the pub as four-wheel-drive vehicles set off down the unpaved road. By mid-morning Birdsville was deserted except for a couple of trucks clearing away 80,000 empty beer cans. In the pub the locals reclaimed their regular places at the bar and pondered over a quiet beer. Finally someone muttered: "Thank heaven that's over." Outside, the silence of the Outback had returned, and over the airfield the kite hawks—minus one—wheeled and hovered, once again in control.

The Rises and Falls of Henri-Marie Coanda

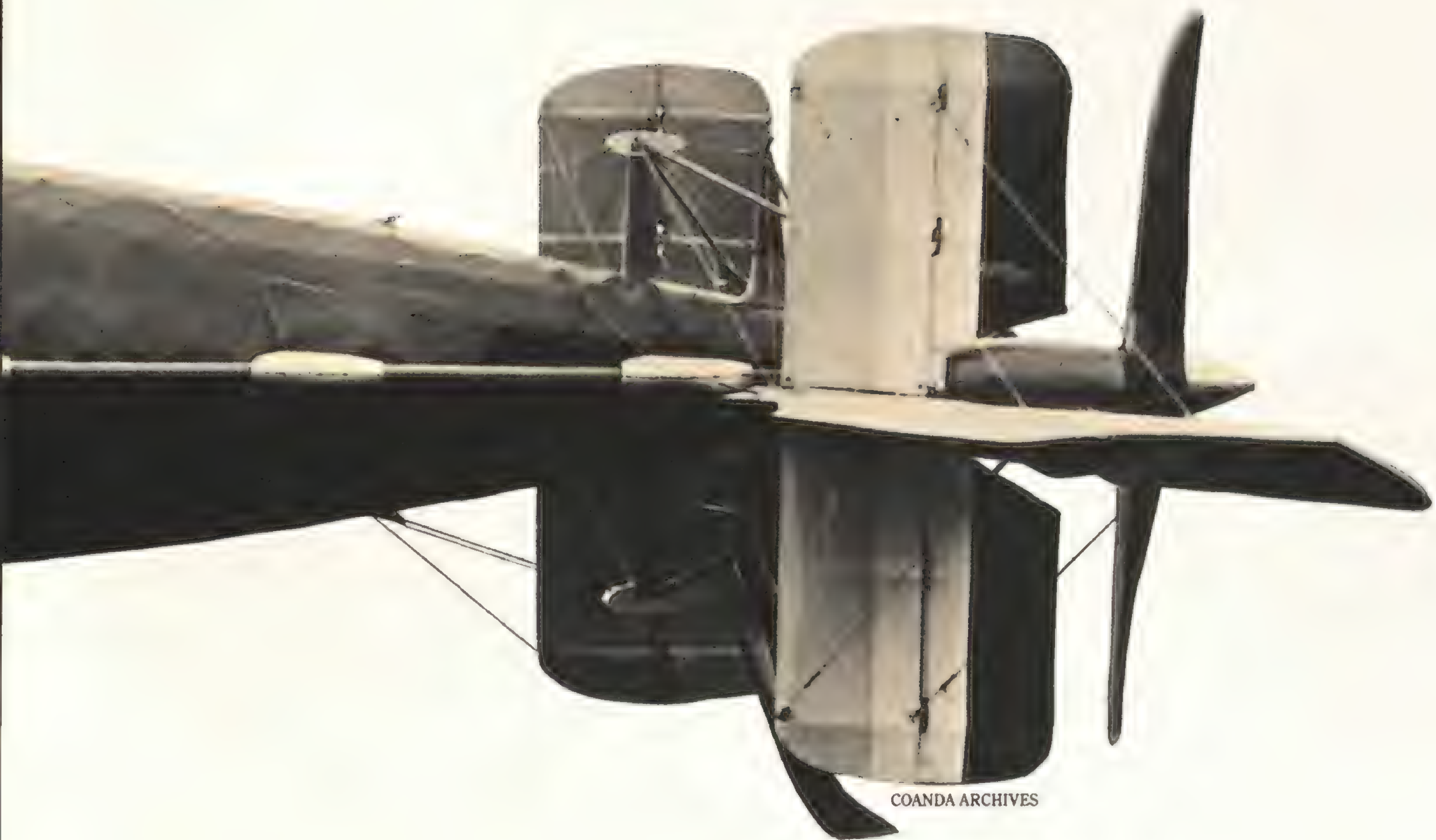
Some credit this talented Rumanian with the first jet—and perhaps the first jet crash.

by G. Harry Stine

It is a terrible day for flying. The weather is cold and windy, with low clouds. An airplane is wheeled out of one of the sheds at Issy-les-Moulineaux, a field on the edge of Paris. A young man supervises the workers and makes a final inspection of the engine in the airplane's nose. This engine is something totally new and unique. The engine is a jet—not in the modern sense of the word, but a kind of jet nonetheless.

At its heart is a precision-made centrifugal air compressor powered by a liquid-cooled reciprocating engine that spins the compressor up to high speed. Air is drawn in through a circular opening in the nose, compressed, then mixed with the piston engine's exhaust before being enriched by gasoline sprayed from a row of nozzles. The resulting mixture is ignited, creating hot gases that rush through two asbestos-lined ducts on either side of the molded-plywood fuselage and exit with a roar to the rear, producing thrust.

During tests in the laboratory, the engine had produced thrust—not much, but if the calculations are right it should be enough to move an airplane. However, during these static tests the



COANDA ARCHIVES

COANDA ARCHIVES

The 1916 bomber had twin engines buried in the fuselage and connected by shafts to pusher propellers.

Coanda (left) and Giannini Caproni, who later founded an aircraft firm in Italy, built this glider in 1908.

2,370-degree-Fahrenheit heat from the jet exhaust nearly roasted the young designer as it washed past the open cockpit, so he added metal plates to the two exhausts to angle the jet blast away from the airplane.

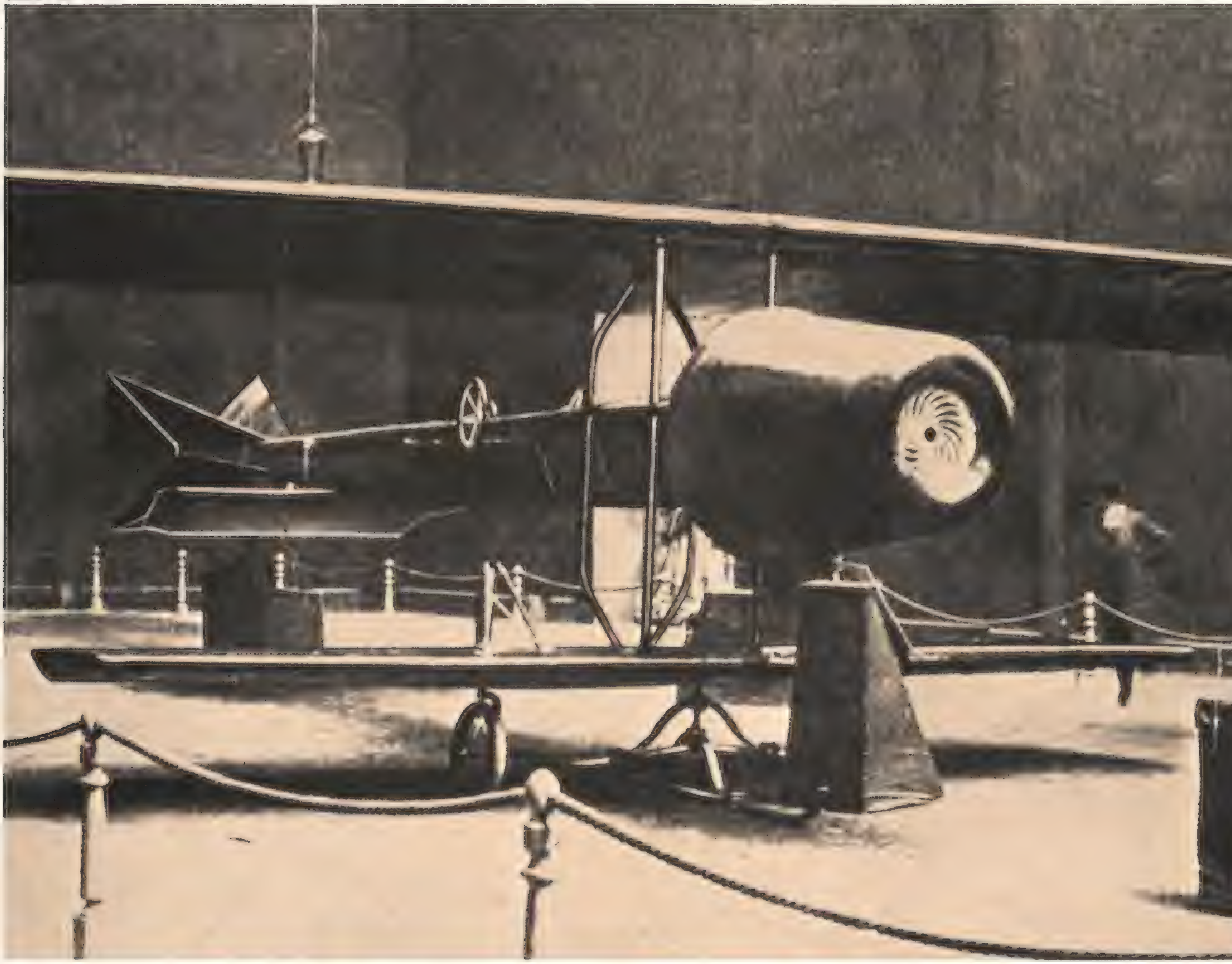
No flight has been planned for this cold Saturday morning and no reporters are present to record it. The airplane will remain on the ground so that the young man can get the feel of the machine before making the first test hop.

Finally, all is ready. The pilot starts the piston engine to power the compressor, and his mechanic signals that it is running properly. The pilot begins to valve gasoline into the spray nozzles of the jet ducts. The airplane begins to move, but only sluggishly, so the pilot opens the throttle.

Suddenly the jet exhausts start spitting flames. Incredibly, the flames don't spurt outward at an angle from the airplane, as the metal plates are intended to direct them. Instead, they cling to the airplane's sides.

The pilot ignores his increasing speed and concentrates on the behavior of the jets, trying to adjust the flow of gasoline so that the flames go back inside the exhaust pipes where they belong. He never notices the mounted cavalrymen, whose riding field this is, as they scatter

COANDA ARCHIVES



The 1910 "jet" led a short, happy life. With its cantilever wings, unusual tail, and lack of propeller, it was the sensation of the Salon Aéronautique. But less than a month later it was gone, the exact circumstances of its disappearance unknown.

out of his path. When he finally looks up, he sees the walls of Paris rushing toward him. No room to stop. No room to turn. No time to do anything but try to zoom over the walls.

The young man has never taken a flying lesson in his life. He pulls back on the controls in an attempt to get the airplane to climb. The craft rises steeply . . . stalls . . . crashes to the ground.

The pilot is thrown clear of the wreckage. Within moments he regains consciousness and watches as his airplane burns a few yards away. He feels as though every tooth in his head has been knocked loose.

The pilot's name was Henri-Marie Coanda (pronounced "kwan-dah"), and according to his own account, the date of that spectacular series of events was December 10, 1910, only seven years after Kitty Hawk. What actually happened to the 25-year-old Coanda and his airplane on that bleak winter morning outside Paris is to this day the subject of controversy.

The preceding description of events is exactly what Coanda recounted to me in 1962. A friend of Coanda's, Major Victor Houart, reported that he witnessed the flight; his account appears in his book, *L'Histoire de l'Aviation Racontée à Mon Fils* —"The History of Aviation as Told to My Son." [However, his history adds nothing to Coanda's description; efforts to obtain more information about Houart and his claim to have seen Coanda's feat have proved fruitless. The book's title suggests it may have been a children's book, and his posing as a witness may have been a device of fiction.—*Ed.*] One aviation historian, the late Sir Charles Gibbs-Smith, believed that the flight had never taken place at all. He based this on the observation that the Paris newspapers contain no accounts of it and reporters covered *all* early flights. Even the patent papers for Coanda's engine fail to indicate the presence of the spray nozzles for fuel—the critical element necessary to qualify the primitive engine as a jet.

Never a stranger to controversy, Coanda was a gentleman and an individualist with a brilliant mind. Born in Bucharest, Rumania, in 1886, he was at home in many fields of science and technology and left his stamp on aviation, fluid dynamics, architecture, sculpture, biological engineering, and water purification. His father, Constantin, had been a hero in the Turkish war of 1877 and later became war minister of Rumania. Young Henri received a good education, and while he was attending a military academy near Berlin, he began to study Otto Lilienthal's gliding experiments at nearby Spandau.

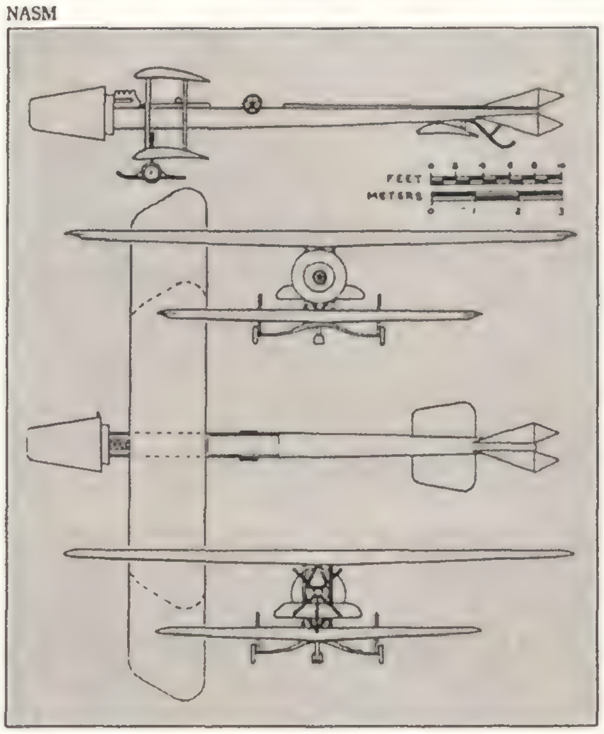
He also traveled widely, and on his return from a trip to North Africa in 1906 he stopped in Nice to visit Captain Ferdinand Ferber, a man who was regarded at the time as Europe's leading authority on heavier-than-air flight. The visit changed Coanda's life.

Ferber had been working on a Chanute-type glider powered by an Antoinette engine. The glider was fixed by a cable to a tower so that it could fly a circular path like a modern U-control model airplane. According to Coanda's autobiography, Ferber's system of propulsion "irritated" him. "It is the string pulling your kite that bothers me," Coanda told Ferber. During this visit he conceived and described to his host the principle of his unique engine.

Ferber, impressed, sent Coanda to Paris to see Ernest Archdeacon, Gustave Eiffel, Paul Painleve, and Louis Blériot, all of whom were deeply involved in early manned flight. But none of them could provide Coanda with the information he sought on aerodynamics, so he decided to gather the data himself. In December 1907 he built a model of a jet-propelled airplane and put it on exhibit in the Sport Halle in Berlin. His first experiment in jet-propelled flight was with a model airplane powered by a pyrotechnic skyrocket; he flew this in early 1908 near Bucharest, but it crashed. Coanda needed more background and more data. The place to get it was the universities of Europe. And get it he must, because by that time Coanda's interest had become an obsession. He'd been at Le Mans, France, on August 8, 1908, when Wilbur Wright flew for the first time in Europe, setting off wild enthusiasm there for manned

NASM

NASM



Photographs and drawings of the 1910 airplane clearly show a centrifugal compressor (top) driven by a piston engine, so Coanda's turbopropulseur *had elements of a true jet. The critical stage—injection of fuel into the compressed air—is not documented.*

flight. And Coanda had spoken with Wright himself.

He attended lectures at Belgium's University of Liège, where he shared rooms with an Italian aeronautics student, one Giannini Caproni (who in 1940 would build the Campini-Caproni CC.2, the sort of jet-propelled airplane Coanda was dreaming of). Coanda then went to Paris, where he graduated with the first class of the Ecole Supérieure de l'Aéronautique et Froid.

He turned again to Eiffel for help, and the engineer came through with a lift-drag balance used to take measurements in wind tunnels. But the only wind tunnel available to him was a small and limited one belonging to Eiffel. So Coanda decided to invert the principle: if he couldn't blow air past a stationary test model in a wind tunnel to test his ideas, he'd move himself and his equipment through the air. Coanda mounted the Eiffel lift-drag balance on the front of a Chemins de Fer du Nord railway locomotive, and during the cold winter nights of 1908-1909 he rode the train back and forth along the Paris-St. Quentin line at more than 60 mph. It was the middle of winter and the wind was bitter, but Coanda got the first aerodynamic data on the sort of thick airfoil sections that are still prevalent today.

Armed with this data and the financial assistance of his father, Coanda began the construction of his jet. He had Pierre Clerget, master mechanic of French "aero" engines, build his *turbopropulseur*—the engine. By November 1910 he was finished, and the Coanda jet was displayed in the Salon Aéronautique in Paris. Less than a month later, it was gone forever.

In spite of this enormous financial and technical loss, Coanda was still obsessed with flying. He had a shop full of spare parts, so he set to work on a twin with two Gnome rotary engines running in opposite directions to cancel the enormous torque forces this type of engine generated. Despite its ingenious features, the airplane drew little interest at a military competition in 1911.

Coanda was now nearly bankrupt, and his father could no longer finance him. He sold his workshop, his tools, his spare engines—even the pet panther he kept in his apartment. And there were worse misfortunes: in 1911, shortly after he'd married, his infant daughter Monique had died. (The half-sized sculpture of Christ that Coanda made for her grave can be found today in the Church of Migne Auxantes near Poitiers, France.)

But his outlook soon brightened. As a result of the jet and the twin, he caught the attention of Sir George White of the Bristol Aeroplane Company at Filton, England. White sent Captain Bertram

COANDA ARCHIVES

At Bristol, Coanda designed a winning biplane, but his monoplane (foreground) was a failure.

Dickson to see Coanda in Paris and offer him the position of chief engineer.

Coanda thrived at Bristol. He played a major role in developing the Bristol Scout and F2B Bristol Fighter, but his greatest achievement was the Bristol-Coanda, Britain's first military monoplane. Piloted by Harry Busteed at the Larkhill Trials on July 15, 1912, it achieved a speed of 73 mph and a range of 420 miles—phenomenal performance at the time. But a Bristol-Coanda lost a wing while undergoing British Royal Flying Corps tests, and the RFC was forbidden to buy any more. (The Bristol-Coanda was the last British military monoplane until the Royal Air Force accepted the Hawker Hurricane in 1936.) The basic design was flexible enough that nearly all Bristol-Coanda monoplanes were converted to B.R.7 biplanes, which sold widely in Europe until 1914, providing Coanda with a second fortune from the design royalties. He also played a major role in the early designs of the Bristol Scout and F2B Bristol Fighter.

When World War I broke over Europe, Coanda left Bristol and offered his services to the French as an observation pilot with the 22nd artillery regiment of the Foreign Legion at the First Battle of the Marne. But the French knew of his achievements as an aeronautical engineer, and he was soon assigned to the government aircraft factory at Delaunay-Belleville, where he built a small, fast observation biplane.

Military airplanes quickly evolved from pure observation craft into bombers and fighters, and Coanda's artillery observation airplane was no longer needed. What the French had to have were fighters and bombers. So Coanda was asked to design a bomber that would be a larger, twin-engine version of his observation airplane.

The Coanda pusher bomber is hardly remembered today, although it mounted a sophisticated recoil-less rocket cannon

Coanda developed at the suggestion of the famous French fighter ace Charles Nungesser. But the bomber was designed for the new liquid-cooled Hispano-Suiza engines, and fighter aircraft got priority for these. Coanda was ordered to design a more conventional bomber powered by U.S.-built Liberty engines. He complied, and the result was a virtually forgotten airplane—it was never even given a name—that outperformed anything then in the air in terms of speed, range, and bomb load. By the time he finished it, World War I was over. With the war's end, Europe's aviation industry collapsed.

Around this time, Coanda designed gasoline tanks and railroad tank cars made from concrete because steel was in short supply. He also developed a method of pressure-forming concrete into a form known today as gunnite and used in the construction of buildings and swimming pools. Together with aviation pioneer Louis Blériot, he formed a company to build prefabricated concrete houses, many of which are still in use in France today. But shortly after Blériot's death, the firm failed and Coanda went bankrupt again.

Later, he recounted that in 1932, having lost his third fortune, he decided to find out why his 1910 jet had failed. In particular, the behavior of the flames from the jet pipes had bothered him for years. Now he had some time on his hands. And he had a place to work in Paris.

As it happens, Paris is the only city in the world where pressurized air is available as a public utility, like water or gas. Tap the air mains of the city of Paris and you have a practically inexhaustible supply for experiments. What would happen, Coanda wondered, if he blew air along a surface instead of moving the surface through the air? He tried it.

To his amazement, he discovered that when a sheet of air passes over a curved surface, it tends to follow the curves instead of flowing straight ahead. The tendency of a fluid stream like air or water to follow a surface is known today as the Coanda Effect, so named by Albert Metral of the Sorbonne and considered one of the most important discoveries in the field of fluid dynamics (see "Making Air Turn Corners," right).

Coanda spent his last years consulting for several United States firms and received more than 30 U.S. patents, including one for the first hydraulic automobile transmission. He lived in Paris until 1970, when he returned to Rumania. There, he was immediately made president of the National Institute for Scientific and Technical Creation. He died on November 25, 1972.

Whether Henri Coanda built the first true jet will probably be argued interminably. And as to whether that first test hop constituted a flight, Coanda's account will never be proven.

Perhaps it's time to lay the controversy to rest. Although there is no direct evidence linking the 1910 airplane with Coanda's interest in airflow 22 years later, his early years designing airplanes clearly kindled a curiosity that eventually led him to discover the phenomenon that bears his name. That alone assures Henri-Marie Coanda an honored place in aviation history.

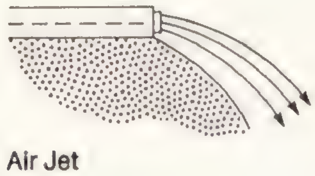
NASM

Making Air Turn Corners

The Coanda Effect describes an apparent quirk: when water is poured from a pitcher of just the right shape, it will curl back around the lip of the spout, run down the side of the pitcher, and get all over you. Today, the phenomenon is put to good use in numerous practical applications, such as the tiny fluid amplifiers developed by the U.S. Army's Harry Diamond Ordnance Laboratories for environments where electronic equipment would be destroyed by acceleration or heat. In fact, Coanda was awarded a special prize by that organization for his discovery of the phenomenon.

Airplane designs such as the NASA Quiet Short-Haul Research Aircraft, the Soviet Antonov An-72, and the Boeing YC-14 use the exhaust of jet engines blowing across the top of a wing to enhance lift. Instead of exiting straight back out of the engines' tailpipe, the flow follows the curve of the wing's trailing edge flaps, blows rearward and downward, and helps push the airplane up as well as forward.

Thrust from the Boeing YC-14's mammoth turbofans (top) followed the upper surface of its flaps due to the Coanda Effect, a phenomenon in which a jet of air adheres to an adjacent curved surface (below). Deflection of the air downward helps to lift the airplane and enables it to operate from very short, unpaved airstrips. When all is said and done, it is the discovery of this peculiarity of airflow that is Coanda's enduring legacy to the discipline of aerodynamics.



Air Jet

YC-14 Turbofan

"You Have a Fire!"

After Chuck Yeager exceeded Mach 1 in the Bell XS-1 in 1947, the vast dry lakes around California's Edwards Air Force Base were rocked with sonic booms as X-series aircraft pursued higher and higher Mach numbers. Among the test pilots who frequented Pancho Barnes' Happy Bottom Riding Club by night and flew for the Air Force and the National Advisory Committee for Aeronautics by day was A. Scott Crossfield, who in 1953 was the first to crack Mach 2, flying the Douglas Skyrocket.

When the X-15 appeared on the horizon in 1952, Crossfield was immediately smitten. The rocket-powered craft was designed to bridge the gap between atmospheric and space flight at speeds approaching Mach 7 and altitudes of nearly 70 miles. The following year Crossfield quit NACA to join X-15 contractor North American Aviation as a project consultant. His goal was to oversee the X-15 program from first flight to last.

The saga of the extraordinary X-15, which in 1962 set an altitude record of 314,750 feet that still stands, is detailed in Crossfield's book Always Another Dawn—The Story of a Rocket Test Pilot, *written with Clay Blair Jr. In chapter 41, Crossfield prepares the X-15 for its third powered flight.*

So far we had conducted most of the X-15 flights—circular patterns—within about twenty miles of the Edwards base. Now as we advanced in our flight-test program, we planned to drop the ship farther out, to enable me to fly in a straight line and subject the X-15 to high-speed and high-altitude maneuvers to define her safe-flying limits. We selected the new, more distant launch points so that a flight would always begin over one of the dry lakes. If the engine failed or some other malfunction occurred, I could land. If it performed as expected, I could fly back to Edwards on my own steam and land on Rogers.

Two launching points that appealed to us were Cuddeback and Three Sisters Dry Lakes, about seventy miles from Edwards as the crow, or rather the X-15, flies. But our plan to launch over these lakes was complicated by the rapidly changing and generally deteriorating desert weather. Rain dampened Cuddeback and Three Sisters. Some "experts" said that an emergency landing on these lakes would be like landing in a marsh.

Everyone who has ever flown at Edwards has his own unscientific and usually inaccurate method for testing the "dampness" and strength of the dry-lake beds. One system is to poke a rod in the sand. I flew up to Cuddeback in a light plane to make my own test. It was damp but adequate, and since I would land there only in an emergency and I really did not anticipate an emergency, I proposed the longer-range launch at Cuddeback, rather than continue to idle around Edwards and delay the program.

Roy Ferren, North American's Chief Flight Test Engineer, was against launching over Cuddeback. He argued for more experience with launches closer in, over Bouquet Canyon Reservoir, say, which was within glide distance of Lake Rosamond, then in better shape than Cuddeback. Ferren made a good case and I conceded he had a point. In light of the near-disaster that followed, it was probably fortunate for both me and the X-15 program that he prevailed.

There was nothing in the take-off and pre-launch routine that day, November 5, to indicate a new and formidable crisis was in the making. The X-15 and B-52 were tight as ticks: no valves or regulators were leaking, the nitrogen pressure, APUs [auxiliary power units], Lox [liquid oxygen fuel] top-off system, pressure suit—everything—all perfectly tuned, so much so that I reported by radio:

"Take out the X-15 handbook, Q.C. See what the instrument-panel gauges should read. That's what I've got."

We bore down on the Bouquet Canyon Reservoir launch point at Mach 0.82 and 45,000 feet. After thirteen flights in the X-15, including the [three] launches, I worked almost routinely in the cockpit. I turned on the rocket-engine master switch, shifted to X-15 oxygen, and finally flashed the green launch-light in Jack Allavie's cockpit in the B-52. I was hoping that day, if all went well, to inch the X-15's speed to Mach 2.6 or about 1,700 miles an hour, and to fly to 80,000 feet. At higher speed it was easier and safer to make our demonstration points and because of this neither NASA nor the Air Force seemed intent on enforcing the Mach 2.0 speed restriction on North American.

"DROP."

For the fourth time I heard the familiar "kerchunk." The X-15 fell away in free flight. Striving for a fast lift-off I leveled the ship with my right hand and flicked the rocket switches with my left. I lighted number two and number four barrels on the lower motor first. Then I flicked number two and number four barrels on the upper motor. Then number three and number one on the upper. When I threw the toggle on number three and number one of the lower motor, the last two barrels, I felt a tremendous jar. The whole airplane shook violently, an explosion that seemed to be right behind me. My first thought was that the APU had blown again.

The ship was picking up speed. My eye swept to the APU gauges. They were in the green. The APU had not failed. I was puzzled. Then I noticed that the pump for the lower rocket motor was overspeeding and shutting down, indicating a malfunction. An amber warning light flashed on in the cockpit. The flight was done before it began. I shut off the four switches for the lower motor.

About five seconds had ticked by. At that instant chase pilot Bob White, who was flying his F-104 close by the tail of the X-15, snapped on the radio: "Looks like you had an explosion in the rocket motor." Almost simultaneously a fire-warning light flashed on my instrument panel.

For a rocket-plane pilot this is a pure and simple moment of truth. In the past, four rocket planes had exploded and caught fire: the X-1-A, X-1-D, X-2, and "Queenie" [X-1-3]. Each was demolished. Two choices lay open: to pull the ejection-seat handle and bail out, or to ride the ship out and try to save her. The thought of a bail-out never

occurred to me. I'm paid to bring airplanes back, not throw them away. My course was set when I first stepped in the airplane.

Working swiftly to minimize the chance that the fire might spread, and to prevent the ship from flying beyond reach of Rosamond Dry Lake, I shut down the rocket engines and closed the fuel lines. All the while I held the ship in level flight.

Chase [pilot] White, his voice rising with concern, said: "You have a *fire*!" From his position in the F-104 he could see the flames streaming from the rear of the X-15.

I had completed the shut-down and was thinking ahead to the emergency jettison when Bob White . . . radioed:

"You have a fire! *Please* shut down."

With no thrust to maintain her air speed, the X-15 was sinking rapidly. I glanced at the altimeter: 32,000 feet. In two minutes I would be on the ground. I spoke on the radio:

"Going to jettison NOW."

The heavy stream of Lox and Walc [water-alcohol fuel] and hydrogen peroxide trailed through the sky behind me. The fire-warning light flickered out. I radioed White:

"Bob, I'm going to put down on Rosamond. Please let me know when we have reached the center of the lake." I was thankful then that Roy Ferren had vetoed the Cuddeback launch. It might have been a mess.

"Jettison looks good," White reported. "I don't see any sign of the fire now."

"Where'd it come from? Could you see?" I asked.

"I think it was the lower engine."

"Thank you," I said. That fact tied in with the overspeed and shutting down of the lower pump. In my mind I envisioned the complex plumbing system, trying to guess what might have happened. How long would it take to fix it? How much more delay would these supposedly reliable engines, with so much time on them, cause us?

The jettison was completed in 114 seconds. There was still a little fuel left in the tanks. The powerful suction of the rocket engine usually burns them bone dry. In the less efficient jettison it is not possible to get all the fuel out. The X-15, I knew, would come in more than a thousand pounds heavier than the previous three landings. My thoughts turned to the landing gear. We had been planning to beef it up following this flight, to give us an added margin of safety. However, I was confident that the gear would hold.

Chase White radioed: "We're almost to the east edge of the lake now."

I was surprised. We should have been approaching the lake from the south. In another fifty seconds I would be touching down.

"Almost *where*?"

"Pardon me. Almost to the *edge* of the lake."

"Thank you." I could tell from White's radio transmissions and from others, that the entire X-15 flight-test group was frozen in tension. Every man was aware of the potential danger of fire in a rocket plane. Many of them no doubt expected to see an explosion smear across the sky at any second. To put them at ease, as I turned on downwind I cracked on the radio:

"Sorry. I'm going to miss getting the data coming in here."

Chase White chanted my decreasing altitude on the radio: "8,000 . . . 7,000 . . . 6,000 . . . 5,000 . . . " I blew the ventral

Its third powered flight ended with a split fuselage, but within a month X-15 no. 2 was ready to fly again. UPI/BETTMANN

WIDE WORLD

A. Scott Crossfield flew 11 of the X-15's initial powered flights.

fin and got set for the approach, holding the X-15 nose high. I keyed my radio mike so that I could no longer receive radio transmissions which might be distracting. I lowered the tail skids and nose wheel, pulled the flaps, and felt for the lake bed.

The skids dug in gently. The nose slammed down hard and the ship plowed across the desert floor, slowing down much faster than usual. Then she came to a complete stop within 1,500 feet instead of the usual 5,000 feet. Something was wrong; the skids failed, I was sure. Not knowing the cause of the trouble and with the fire still very much in my thoughts, I remained buttoned up in the fireproof cockpit. My radio was dead. I sat alone, waiting in silence.

The emergency helicopter reached the X-15 first. I saw North American's flight surgeon, Toby Freedman, and Brian Lauffer jump out of the chopper and run toward the ship. A good sign, I thought. She wasn't on fire. I opened the canopy and removed my helmet.

Toby was the first to speak. "The plane's busted in two," he said.

"What?" I asked. I couldn't believe it. Quickly I scrambled out of the cockpit. What I saw almost broke my heart. The fuselage had buckled immediately aft of the cockpit, two hundred and thirty inches back from the nose. Her belly had dragged in the sand, causing the abrupt deceleration on the lake. The rocket chambers which had exploded at launch were a shambles.

When Stormy [chief engineer Harrison Storms] and Sam Richter [communications manager] first heard the report of fire on the radio, they jumped into a light plane at Edwards and flew immediately to Rosamond Lake, landing alongside the broken bird. They ran up, staring in disbelief. A minute later the fire trucks arrived. One of the firemen, an old friend who had probably met me on the lake in his truck a hundred and fifty times, cried quietly as he sprayed the broken plane with water. I felt like crying myself. At first look it seemed to all of us that that obstinate filly would never break to bit and was mocking our efforts in the grand plan for space flight.

I flew back to Edwards in the light plane. There was not much talk. I changed out of the pressure suit into street clothes. Toby Freedman examined me briefly for the record. Then we all flew back to the airplane again. By then the wreckers were there and, sad to say, some newspaper photographers. It was silly, but when they took their pictures I smiled. It was a vain attempt to laugh away our anguish, to tell anybody who might care that we were not defeated—not by a long shot. And the truth of the matter was, we weren't. Our course was set on the stars.

Always Another Dawn—The Story of a Rocket Test Pilot by A. Scott Crossfield. Available from Ayer Company.

"The Satellite Sky" Update/13

These regular updates to **"The Satellite Sky"** chart will enable readers to keep their charts up to date. Additions can be clipped and affixed to the chart at the appropriate altitude.

Deletions

90 to 300 MILES

Cosmos 1958
down 3-21-89

Cosmos 1993
down 3-27-89

Cosmos 1984
down 2-13-89

Cosmos 2000
down 3-3-89

Cosmos 1986
down 2-11-89

Progress 40
down 3-5-89

Cosmos 1990
down 2-11-89

Soyuz TM-7
down 4-27-89

300 to 630 MILES

Cosmos 1868
down 3-2-89

Launched but not in orbit

90 to 300 MILES

Cosmos 2003 USSR photo recon	2-17-89	down 3-3-89
Cosmos 2005 USSR photo recon	3-2-89	down 4-25-89
Cosmos 2006 USSR photo recon	3-16-89	down 3-31-89
Cosmos 2017 USSR photo recon	4-6-89	down 4-19-89
Cosmos 2019 USSR photo recon	5-5-89	down 5-18-89
Foton 2 USSR research	4-26-89	down 5-17-89
Progress 41 USSR research	3-16-89	down 4-25-89
STS-29 USA research	3-13-89	down 3-18-89
STS-30 USA research	5-4-89	down 5-8-89

Inoperative but still in orbit

300 to 630 MILES

Cosmos 1934

CAC denotes Cape Canaveral, a launch site south of Kennedy Space Center that is used by the Air Force.

New launches

90 to 300 MILES

Cosmos 2007
3-89 TT

Cosmos 2018
4-89 PL

Cosmos 2020
5-89 TT

Cosmos 2021
5-89 TT

Cosmos 2025
6-89 PL

Delta Star
3-89 KSC

Resurs-F
5-89 PL

300 to 630 MILES

Cosmos 2004
2-89 PL

Cosmos 2016
4-89 PL

Cosmos 2026
6-89 PL

Meteor 2-18
2-89 PL

630 to 1,250 MILES

Cosmos 2002
2-89 PL

Cosmos 2008-15
3-89 PL

3,100 to 6,200 MILES

EXOS-D
2-89 TAN

6,200 to 13,700 MILES

Cosmos 2022 & 23
5-89 TT

Cosmos 2024
5-89 TT

GPS-1
2-89 VAFB

GPS-2
6-89 CAC

21,750 to 22,370 MILES

Kopernikus-1
6-89 KOU

Unnamed
5-89 CAC

Raduga 23
4-89 TT

Superbird A
6-89 KOU

TDRSS-4
3-89 KSC

JCSAT-1
3-89 KOU

MOP-1
3-89 KOU

TELE-X
4-89 KOU

Reviews (&) Previews

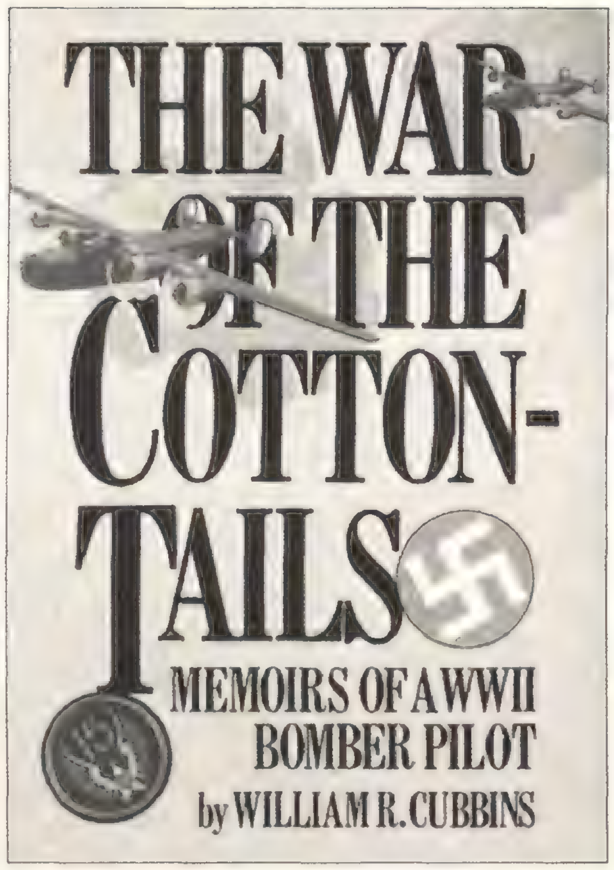
***The War of the Cottontails: Memoirs of a WWII Bomber Pilot** by William R. Cubbins. Algonquin Books of Chapel Hill, 1989. 267 pp., b&w photos, $17.95 (hardbound).*

The B-24 Liberator was one of two heavy bombers employed by the U.S. Army Air Forces during World War II. Somewhat awkward in appearance, the big four-engine airplane had a peculiar grace in flight and could carry more bombs over a greater distance than its B-17 running mate. Yet it proved less survivable than the B-17 against enemy fighters, and was of more use in southern Europe and the Pacific than in strikes against the heavily defended heart of Germany.

The B-24's most notable feature was its twin-tail construction. The 450th Bombardment Group of the 15th Air Force, based in the heel of Italy, painted the twin rudders white, a decorative flair that distinguished that unit from other B-24 groups and earned it special mention in German propaganda broadcasts. "Axis Sally" derisively called the 450th the "White-Tail Liberators from Southern Italy," but the Americans preferred to be known as the Cottontails.

William Cubbins was just 20 when he joined the unit as a pilot in late April 1944. His first combat mission was against Rumanian oil facilities at Ploesti, source of a third of Germany's oil and one of the most heavily defended targets on the continent. Over the next two months, he flew 14 more missions in southern Europe and survived being shot down three times. The first time, he and his crew were able to bail out over friendly territory. Barely a month later, they managed to crash-land their crippled B-24 at a British airfield. Their luck ran out, however, when they had to jump from their third stricken bomber over Giurgiu, Rumania, where they were quickly captured.

The War of the Cottontails is colorful, exciting, and highly personalized. The now-retired Air Force officer apparently did considerable research in official records to ensure depth and accuracy. Cubbins'



account is particularly valuable for its lengthy description—more than half the book—of life in a Rumanian POW camp, which differed considerably from the experience of those fliers held by the Germans. The author and his fellow prisoners were able to outwit their Rumanian captors in many ways, ample proof of Cubbins' contention that, however helpless a POW may be, he is "not *fully* at the mercy of the enemy, nor is his condition *completely* hopeless." Fortunately for the more than 1,000 Americans held near Bucharest, Rumania's collapse in August 1944 led to a thrilling and almost unbelievable rescue that quickly brought them back to Italy.

Cubbins' memoir invites comparison with John Muirhead's earlier *Those Who Fall* (Random House, 1986), another personal account by a 15th Air Force bomber pilot. Muirhead flew B-17s and fell into Bulgarian hands, so his story nicely complements Cubbins'. Together, the books provide a revealing picture of what it was like to fly heavy bombers from Italy against southern Europe and to experience the uncertainty and helplessness of Balkan wartime captivity.

—Stanley L. Falk is former chief historian of the Air Force and author of several books on World War II.

***Night Launch** by Senator Jake Garn and Stephen Paul Cohen. Morrow, 1989. 285 pp., $18.95 (hardbound).*

Senator Jake Garn (R-Utah) offers a compelling view of the inner workings of NASA in his novel, *Night Launch.*

Intertwined with a realistic plot involving space-based terrorism are glimpses of the space shuttle program that only an insider could reveal. The behind-the-scenes details of mission planning add authenticity and give this thriller the feel of a fast-paced documentary.

Night Launch opens with the formation of the Peace Flight Program (PFP), a series of spaceflights with international crews expected to culminate in a U.S.-Soviet mission to Mars. Unknown to all, the first crew to participate in the PFP—nicknamed the PF Flyers—includes an undercover terrorist from "Das Deutschland Syndikat," a neo-Nazi organization that plans to use the shuttle and crew as a bargaining chip to free 10 of its members from an Austrian jail. The terrorist makes his move five days after liftoff, handcuffing his fellow crew members and directing mission control to meet his demands. Time is short: at the time of the hijacking only three days' worth of oxygen remains.

Aboard the shuttle, guns and romance make their debut in space during the struggle for control of the orbiter. U.S. pilot Joey Wells, nicknamed Cowboy, shares a touching moment in the shuttle airlock with his love interest, cosmonaut Aelita Zakharov. And the lives of all crew members are threatened as the hijacker risks puncturing the shuttle's external skin by brandishing a gun.

Although co-author Stephen Paul Cohen supplied the romantic twists and polish, it is Garn's experience as a space shuttle crew

member in 1985 that brings the novel to life. The senator's friendship with key space experts and his political expertise have given him insights uncommon to outside observers. As the crisis in space evolves, Garn taps his knowledge of the inner workings of the White House to outline the politics behind controversial decisions.

The courage of the astronauts is dramatically portrayed, as is the technical expertise of NASA engineers. But *Night Launch* also delves deeper, revealing the commitment to peace and science that bonds members of the space community. The critical role of the ground support team also receives attention often missing in other novels about space.

Night Launch offers suspense, but it also sends a message—that cooperation in space may be the best opportunity to forge greater understanding between adversaries on Earth.

—Congressman Bill Nelson (D-Fla.) traveled into space aboard the shuttle Columbia *in January 1986.*

***Test Pilot**, Aviation Week Video, P.O. Box 308, Mt. Olive, NJ 07828; 1-800-433-0880. VHS or Beta, 70 minutes (including three commercials), $49.95.*

"We're just real people," says Colonel Mike Kostelnik of his fellow test pilots. Real, yes, but definitely different, says this video.

From a brief history that traces the roots of aviation's most exciting profession back to the Wright brothers (who became test pilots by default), the narrative alternates between past and present through a series of interviews with career test pilots, few of them household names.

Most of these men work very hard to avoid giving anyone the impression that they ever get excited. A. Scott Crossfield describes an explosion during a ground test of an X-15 as "a pretty violent activity for a moment or two." Even Robert K. Smyth, a Grumman test pilot during the early days of the F-14 program, admits only to a certain detached sensation as he peered down from his just-fired ejection seat into the fireball of the exploding fighter on the ground.

A counterpoint to such reluctant witnesses is footage of disasters and near-disasters, including some of an F-16 landing on the grass next to a runway with its landing gear stuck in the "up" position. But this video doesn't cater to any obsession with fiery crashes; there's only enough of that to make the point that this can be a risky business.

The video leaves the viewer with the overwhelming impression that test flying is a matter of expanding our knowledge of aerodynamics or a given airplane through a series of small, cautious steps, each one serving as the rung from which the next step is taken. From time to time, though, one can't help wishing that someone would explain what these people are talking about—a sequence at Grumman's factory test flight operation and one at the school for test pilots at Edwards Air Force Base will leave anyone unfamiliar with the jargon absolutely baffled—but there is one jewel that more than makes up for such flaws.

At last year's Farnborough airshow, Soviet test pilot Anatoly Kvotchur flew the new MiG-29 through a routine that stole the show. Afterwards, the producers of this video obtained an interview with Kvotchur, who expressed surprisingly brash confidence in the radical maneuvers he had performed—among them, a tail slide that is a severe test of engine air inlet aerodynamics and of the engine itself. At this year's Paris airshow, Kvotchur's MiG crashed after an engine malfunction during a different maneuver. The contrast between his attitude toward risk and the more restrained attitudes of his colleagues may make the interview one of the most valuable segments in the tape.

—George C. Larson is the editor of Air & Space/Smithsonian.

***Battlehawks 1942** by Lucasfilm Games. Available for IBM PC, XT, AT, PS/2, Tandy. 384K RAM, color monitor. Joystick recommended. Reviewed on IBM XT with CGA and IBM AT with EGA. $49.95.*

"Battlehawks 1942" sounds like the title of a movie or a book. But this sophisticated computer simulation of aerial battles over the Pacific in World War II has some of the features of both, and more. If you have the right computer equipment, you'll be amazed by the action and graphics the program provides. I haven't flown a Navy fighter since the early 1950s, but after playing Battlehawks 1942 for several hours, I felt ready for combat.

An outstanding 128-page manual comes with the program. More like a book than a program manual, it is rich in historical details of naval aviation in the recovery period soon after Pearl Harbor. Four naval battles that turned the tide of World War II in the Pacific—Coral Sea, Midway, Eastern Solomons, and Santa Cruz Islands—are covered in detail. Colorful foldout maps of each battle track major ship movements, air attacks, and ship casualties for each fleet.

As good as the manual is, of course, the main attraction of this package is the computer simulation of these battles. Although the graphics in this program are outstanding, you may be unhappy with this simulation unless you have a reasonably fast computer with a hard disk drive.

The package includes two 5¼-inch floppy diskettes and one 3½-inch microdiskette. A

total of 51 files are used, and the loading of different parts of the program takes several minutes unless you first install the program on a hard disk. Also, although this simulation will run in CGA (Color Graphics Adaptor), the graphics and instruments are much more colorful and easily interpreted in EGA (Enhanced Graphics Adaptor).

The speed of your computer is another consideration. I ran Battlehawks 1942 on a plain-vanilla IBM PC/XT running CGA at 4.77 MHz using one floppy drive. It took four and a half minutes to get into the air, using program defaults to save time—and that was only for a training mission! There were two disk swaps, nine presses of the "Enter" key, eight screen displays, and an aircraft outline (one of 15) to identify as a password before I was airborne.

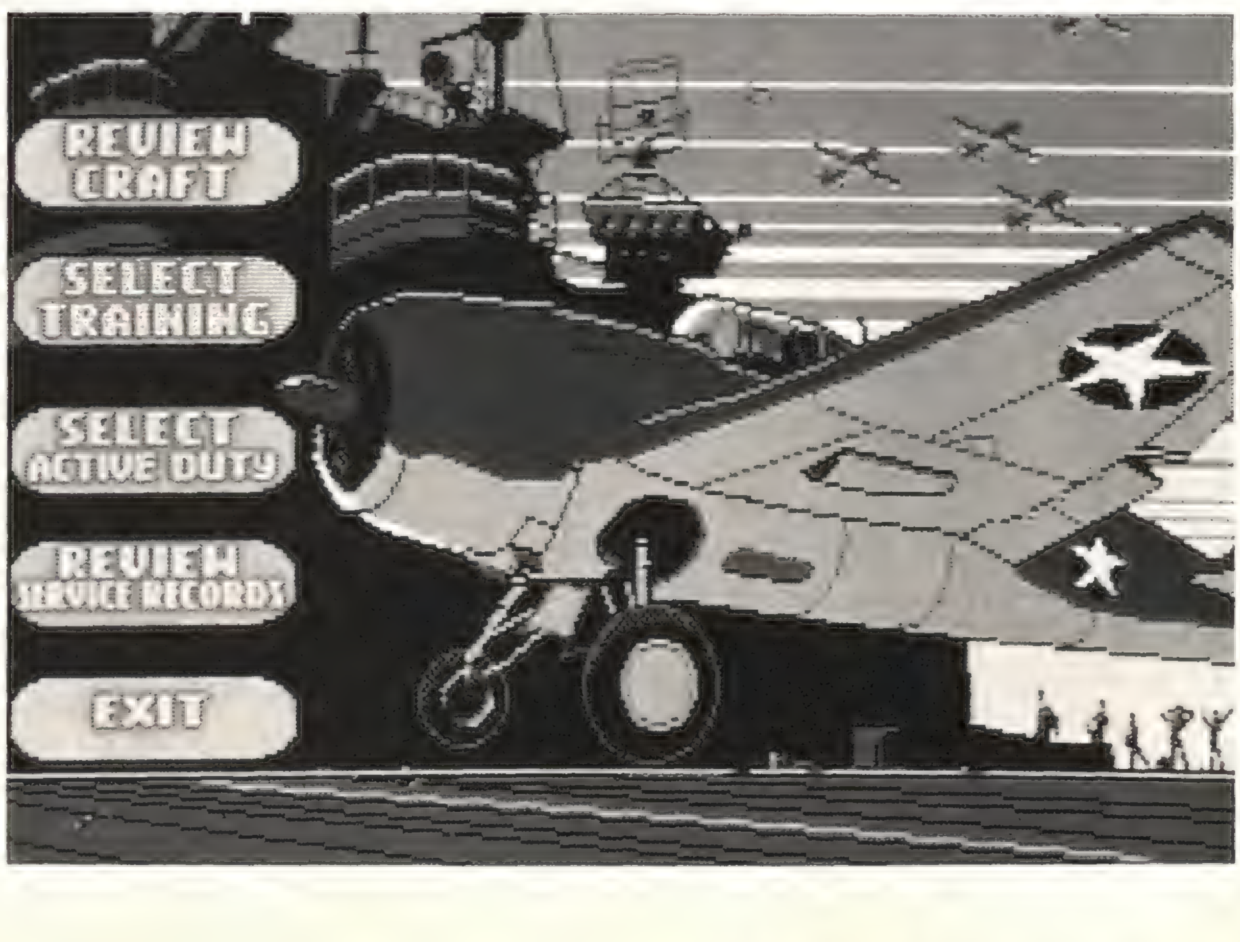
Once in the air, however, I could play for hours, shooting down enemy planes without other delays. While it took some time to get used to the relatively sluggish control at this computer speed, it was usable, and the graphics were surprisingly detailed and colorful for CGA.

On the other hand, I also ran Battlehawks 1942 on an 80386 AT running EGA at 16 MHz with a hard drive. Wow! There were no significant loading delays, the action was fantastic, and the graphics were beautiful. With the right equipment, Battlehawks 1942 is an exciting program with a balanced blend of history and arcade-quality action.

Surprisingly, you don't get to take off or land in Battlehawks 1942, but there are many other activities, as well as a full panel of instruments. You can pilot any of seven U.S. or six Japanese airplanes and fly training or active-duty combat missions. You pick the battle, setting, aircraft, and type of mission—fighter escort, fighter defense, dive-bombing, or torpedo bombing. You can inspect the aircraft (including rotating the side view of each) and use the game's "camera" to record action for later playback, in which you can watch your own aircraft from behind.

The detailed graphics give you a broad, pilot's-eye view. There are even rear gunners in all dive bombers and torpedo bombers. About the only things missing are a helmet, a pair of goggles, and a scarf.

—Fred Blechman is a freelance writer and former F4U Corsair pilot.



Credits

Reunion. Edwards Park is a frequent contributor to *Air & Space/Smithsonian.*

The Logbook. James W. Andersen took up flying to overcome his fear of heights. It didn't work. Andersen piloted airplanes for two years after getting his license but says, "It was white knuckles all the way. The last time I flew was in 1969 and hopefully not again."

BIG. Stephan Wilkinson's last article for *Air & Space/Smithsonian* was "Piaggio" (August/September 1988). He writes "Great Drives," a series of exotic-car road-test reports for *Condé Nast Traveler.*

What Goes Up . . . Greg Freiherr has written extensively about aerospace and medical technology. He currently heads an editorial consulting group in the Washington, D.C. area.

Fast Brake. A frequent contributor to *Air & Space/Smithsonian,* Jake Page is co-author of *Lords of the Air: The Smithsonian Book of Birds,* which will be available this fall from Orion Books.

Japan Is Knocking on Heaven's Door. William Triplett, a Washington, D.C.-based freelance writer, has been observing Japanese culture since researching his first book, *Flowering of the Bamboo* (Woodbine House, 1985), an investigation of the Tokyo Imperial Bank murders. He is currently co-writing a book on the U.S. drug war.

Pan Am's Pacific. Henry Scammell writes frequently about business and aerospace science. He lives on Cape Cod with his wife and four children.

Further reading: *An American Saga: Juan Trippe and His Pan Am Empire,* Robert Daley, Random House, 1980.

Space Craft. Devera Pine is a freelance writer specializing in health and science. She has written for *Omni* and *Ladies' Home Journal.*

Birdsville Bound. Terry Gwynn-Jones lives in Brisbane, Australia. His last contribution to *Air & Space/Smithsonian* was "Reef Encounter" in the August/September 1988 issue.

The Rises and Falls of Henri-Marie Coanda. G. Harry Stine met Henri Coanda when the designer was working in the United States. Stine's last story for *Air & Space/Smithsonian,* "Pushing the Button" (February/March 1988), was based on his experiences as a range safety officer in the early days of White Sands Proving Ground.

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Forecast

In the Wings . . .

To G or Not to G—The jury's still out—will space voyagers on long missions need artificial gravity? Zero-G conditions do have adverse effects, from nausea to calcium loss, but researchers aren't sure what steps should be taken to protect future space travelers.

Data Landfill—NASA is facing an embarrassment of riches. It's planning the most ambitious fleet of scientific spacecraft since the '60s, but the agency can't even keep up with the data already collected: it's "like drinking from a fire hose," says one NASA official. As tapes sit in storage and await examination, scientists scramble to find more efficient methods of data processing.

Black Wings, Red Tails—The 99th Fighter Squadron was the U.S. Army Air Forces' first all-black unit in World War II, and its battles weren't limited to those with the Luftwaffe. "We fought two wars," recalls Louis Purnell, who was a pilot with the 99th. "One was with the enemy and the other was back home—Hitler and Jim Crow."

Autogyro Memories—Neither airplane nor helicopter, the autogyro briefly captured the imagination of the air-minded. (It also became involved in the longest patent lawsuit in aviation history.) Said the *New Yorker* in 1930, "Although the Autogiro looks like something Jules Verne thought of, it will actually land in one's flower garden—or, if one is fussy, in one's neighbor's flower garden."

NASM

"The trailer? Well, my team builds part of the wing for one of the fighter planes. And we felt we needed closer, faster contact with our people in engineering, planning and control.

So I took it to one of our meetings and explained how we lost time tracking down the right people when we needed them.

Well, they zapped that trailer right out here onto the plant floor—like you'd move a sofa. Offices, with desks and equipment for all of our support people. We get fast response now—support and shop people are really a team. We're working closer and that means we can work better.

Sometimes trying to work smarter can be as simple as rearranging the furniture." *—Franki Baysinger, F-18, Foreman*

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